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WATER QUALITY CONTROL STUDY. MIDDLE SNAKE RIVER WATER RESOURCES DEVELOPMENT

Federal Water Pollution Control Administration
Portland, Oregon

January 1968

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WATER QUALITY CONTROL STUDY

FOR REVIEW
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MIDDLE SNAKE RIVER
WATER RESOURCES DEVELOPMENT

By the U. S. DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
Northwest Region
Portland, Oregon

JANUARY 1968

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I. INTRODUCTION

Background

On February 5, 1964, the Federal Power Commission issued a license to Pacific Northwest Power Company for construction and operation of its proposed High Mountain Sheep Project on the Snake River. The Secretary of the Interior petitioned for a rehearing, contending that conservation aspects had not been adequately considered and asking that the record be opened to permit him to supply evidentiary deficiencies. A rehearing, but not a reopening of the record, was granted; and the Commission shortly reaffirmed its original decision. This action, which the Secretary contested, was subsequently upheld by the Court of Appeals for the District of Columbia.

On June 5, 1967, the United States Supreme Court reversed and vacated the Court of Appeals judgments and directed that the case be remanded to the Commission for further proceedings. The court held that the issue of Federal development was never explored by the Commission, that the Secretary should have been given an opportunity to reopen the record and to supply evidentiary deficiencies, and that the Commission should explore all issues relevant to the public interest, including future power demand and supply, alternate sources of power, the public interest in preserving reaches of wild rivers and wilderness areas, the preservation of anadromous fish for commercial and recreational purposes, and the protection of wildlife.

To properly discharge the responsibility imposed upon him by the Supreme Court ruling, the Secretary requested all the affected Department of the Interior resource agencies to undertake intensive studies of the Middle Snake. The studies, the results of which are to be incorporated into a report prepared by the Bureau of Reclamation, are designed to investigate the disposition of this natural resource that will be most in the public interest; and are to provide the factual and technical foundation for the Secretary's presentation with respect to those issues the Court said had not been properly explored in the prior proceedings.

Purpose and Scope

This investigation by the Federal Water Pollution Control Administration was undertaken, in response to the Secretary's request, to explore all aspects of water quality associated with a reservoir development on Middle Snake, and to advise the Bureau of Reclamation on those aspects needing consideration in formulating development plans. This report focuses primarily on needs for downstream water quality control, principally temperature, for fishery enhancement purposes. In addition, project effects on water quality, both downstream and in the reservoirs, under alternative development and operation schemes, have been analyzed, and an appraisal of the need for water quality management facilities in the project structures has been made. The influence of altered quality on present and future uses and the net change to be expected in these uses have been determined, considering both beneficial and detrimental

water quality changes.

Available data on water uses, waste sources, and water quality in the study area were examined, evaluated, and projected to provide a base for this water quality analysis. A FWPCA comprehensive water quality management report for the Snake River Basin is nearing completion, and much of the data assembled for that report were used in this study. Although considerable water quality data have been collected throughout the entire Snake Basin, factual data on quality of the Middle Snake reach are rather limited. Consequently, this study is based primarily on the interpretation and application of past experience at existing projects in the basin rather than on recent water quality surveys in the immediate area.

Acknowledgments

This investigation was aided materially by officials of the U. S. Fish & Wildlife Service, the Bureau of Outdoor Recreation, the Bureau of Reclamation, and Bonneville Power Administration. The use of information listed in the bibliography is also acknowledged.

II. SUMMARY

This investigation, which was designed to explore all water quality aspects associated with a reservoir development on middle Snake River, has disclosed that:

1. Under "without project" conditions, lower Snake River water temperature would exceed objectives in summer and fall, dissolved oxygen concentrations in violation of State standards would occur immediately below Hells Canyon Dam, and unsightly, nuisance level algal blooms would occur on surface waters. These conditions would tend to impair uses of Snake River water for anadromous fishery, recreation and aesthetic purposes. The Fish and Wildlife Service estimates anadromous fish use of the Snake River system under these conditions would total 305,700 annually.

2. Under conditions with a development at Appaloosa, with a re-regulatory dam at Low Mountain Sheep, downstream water temperatures would approximate objectives under somewhat critical weather and flow conditions, operating primarily for power production. The 500,000 acre-feet of storage allocated specifically for temperature control would be required to maintain these objectives under flow conditions predicted after 1985. With artificial reaeration facilities in the re-regulatory reservoir, downstream dissolved oxygen objectives would be maintained. However, reaeration facilities should be designed and operated so as to avoid nitrogen entrainment. Downstream algal blooms may increase, and blooms on Appaloose Reservoir could occur at levels which would impair reservoir recreation and resident fishery use. The Fish and Wildlife Service estimates that, under these enhanced conditions, anadromous fish use of the Snake River system would increase some 62,500 fish annually. Water quality changes attributable to this development would have little effect on recreation and other water uses.

3. A development at High Mountain Sheep, with a re-regulatory dam at China Gardens, would exhibit reservoir and downstream quality characteristics similar to the Appaloosa alternative. Because of the location of these dams and the expected low dissolved oxygen content of the re-regulatory reservoir, however, the Fish and Wildlife Service estimates that all anadromous fish runs above China Gardens would be lost. This means that anadromous fish runs, estimated to total 305,700 under "without project" conditions, would be reduced to 100,800 fish under conditions with development of this alternative.

4. A High Mountain Sheep development without a re-regulating dam would affect water quality and use to about the same extent as the preceding alternative. Some additional loss in downstream fishery potential (3,600 fall chinook annually), due to low DO content and extreme flow fluctuations above Asotin damsite, has been predicted by the Fish and Wildlife Service. Total fishery use under this alternative has been estimated at 97,200 fish annually.

5. Downstream conditions with the Pleasant Valley development, with a re-regulatory dam at Low Mountain Sheep site, are not expected to differ materially from those predicted under the "without project" situation. The impoundment would stratify and produce nuisance-level algal blooms in late summer. Anadromous fish and other water uses are expected to remain at about the same level as that predicted for the "without project" alternative.

6. Pump-back operations, if limited to the months of January and February, are not expected to alter water quality conditions from those predicted for the individual alternatives.

III. PROJECT DESCRIPTION

General

As stated in the introductory chapter, this project study has been undertaken to explore all issues relevant to the public interest in regard to a water resource development on the middle Snake River. Consequently, six alternative plans of development, including a "no dam" plan, have been selected for study by the Bureau of Reclamation. Individual alternatives, and the pertinent data on each, are listed in Table 1. The locations of the alternative sites, together with other physical features of the lower Snake Basin, are shown on the Location Map (inside back cover).

Appaloosa with Low Mountain Sheep Re-regulatory Reservoir

This alternative consists of a 530-foot high dam at river mile 197.5, with a low dam 5 miles downstream to regulate power peaking releases. Drainage area above the Appaloosa site totals about 73,700 square miles. Streamflows at the site for a 30-year study period, projected to 1985 conditions, are shown in Table A-1, Appendix A. These predicted 1985 flows, which average 18,600 cubic feet per second (cfs), were used in project studies involving all alternatives. As proposed in preliminary plans, multi-level turbine intakes, with capability to withdraw reservoir water from five levels, would be incorporated into the high dam structure. Facilities would be installed to reoxygenate waters in the re-regulatory reservoir.

TABLE 1
MIDDLE SNAKE RESOURCE STUDIES
ALTERNATIVE PLANS OF DEVELOPMENT - PHYSICAL DATA

Plans	Damsites			Dam			Reservoir			
	Primary Storage 1/	Afterbay	River Mile	Max. Head ft.	Min. Head ft.	Powerplants Megawatts	Total 1000 AF	Usable 1000 AF	Normal WS Elevation	Min. WS Elevation
1	Appaloosa		197.5	480	250	2100	2410	1500	1510	1350
		Low Mt. Sheep	192.5	150	80	400	45 2/	30	1100	1030
2	Mt. Sheep		189.2	620 3/	322	2800	3590	2700	1510	1280
		China Gardens	172.5	82	35	300	83	43	925	890
3	Mt. Sheep (w/o rereg.)		189.2	600	312	1400 4/	3590	2700	1510	1280
4	Pleasant Valley		213.0	402	209	1700 4/	1050	527	1510	1400
		Low Mt. Sheep	192.5	150	80	400	110 5/	95	1108	1030
5	No Dam Plan (Thermal Alternate for Power)									
6	In Line Pump-back Storage (Plans 1, 2, and 4)									

1/ With multiple level outlets.
2/ Encroachment on Appaloosa.
3/ Requires streambed excavation.
4/ Preliminary estimate of capacity.
5/ Without encroachment.

DATA SOURCE: U. S. Bureau of Reclamation.

High Mountain Sheep with China Gardens Re-regulatory Reservoir

This alternative consists of a 620-foot high dam at river mile 189.2 with a low re-regulatory dam at river mile 172.5. The drainage area is about 1,000 square miles greater than the 73,700 square miles estimated at Appaloosa site, but flows are essentially the same. The Imnaha River enters the Snake a short distance upstream from the High Mountain Sheep site. Of more importance, the Salmon River enters the Snake about 0.7 miles downstream; about 16 miles above the China Garden re-regulatory damsite. Multi-level turbine intakes in the high dam and reaeration facilities on the re-regulatory reservoir similar to those planned under the Appaloosa alternative are proposed.

The high dam and multi-level intakes would be the same as those planned for the preceding alternative. Because of the absence of a re-regulatory reservoir, however, peak generating capacity in the main dam would be halved, and the aeration facilities would be located on the free flowing stream.

Pleasant Valley with Low Mountain Sheep Re-regulatory Reservoir

This alternative consists of a 410-foot high dam at river mile 213.0, with a low re-regulatory dam at river mile 192.5. Drainage area above the Pleasant Valley site is about 73,600 square miles, which contributes on average flow of about 18,000 cfs. No multi-level outlets, or reaeration facilities, have been included in reconnaissance plans on this proposal.

No Dam (Without Project)

Under this alternative, the power obtainable from a middle Snake River hydroelectric facility would be developed in a thermal plant to be constructed outside the Snake Basin. This alternative would have no impact on Snake River water quality.

In Line Pump Back Storage

Under this plan, reversible turbines would be installed in Appaloosa, High Mountain Sheep, or Pleasant Valley dams when needed to meet future peak demands. Present studies indicate this additional capacity may be required after 1985.

IV. STUDY AREA DESCRIPTION

The area considered in this study--the lower Snake River drainage below the mouth of Powder River--covers about 36,300 square miles, of which about 25,400 are in Idaho, 5,600 in Oregon, and 5,300 in Washington. The basin area and appropriate features are shown in the Location Map, inside back cover. Major tributaries are the Salmon (14,100 square miles), the Clearwater (9,640 square miles), the Grande Ronde (3,950 square miles), and the Palouse (3,283 square miles). Although small in relation to other tributaries, the Imnaha drainage, (980 square miles), is an important part of the lower Snake Basin because of its anadromous fish spawning area.

Physical characteristics of the lower Snake Basin vary widely. The upper portion near the High Mountain Sheep damsite is made up of high,

grass-covered plateaus and steep, barren mountains which rise to over 9,300 feet in the Seven Devils Range. This spectacularly scenic area is dominated by the Snake River Canyon, the bottom of which lies some 8,000 feet below the highest Seven Devils peak. Much of the topography in the upper tributary areas (Salmon, Grande Ronde, and Clearwater drainages) is extremely rough, characterized by forested mountains with streams flowing in steep-walled, narrow canyons. Lower portions of the basin consist of rolling agricultural land, used mostly for dry farming. The Palouse Basin, which is an important wheat producing area, falls under this classification.

Climate of the Lower Snake Basin correlates quite closely with elevation, with more precipitation and lower temperatures occurring at higher altitudes. Rainfall averages about 8 inches annually at the mouth of the Snake River, increases to 13 inches at Lewiston, and approaches 50 inches annually in the headwaters of the Clearwater River. Temperatures vary inversely, averaging about 54° F near the mouth, decreasing to 52° F at Lewiston, and 44° F at Challis, Idaho in the headwaters of the Salmon River. Summer temperatures over 100° F and winter temperatures below 0° F are common throughout the basin.

V. WATER RESOURCES OF THE STUDY AREA

Resource Development

Table 2 lists existing dams and those under construction or authorized for construction in the lower Snake River Basin. See Location Map, inside back cover, for the location of these dams. With completion of authorized developments, the Snake River will be a series of pools from the mouth to China Gardens damsite (river mile 172); providing slack water navigation to the Lewiston-Clarkston area. At that time, a 75-mile reach between China Gardens damsite and Hells Canyon Dam will be the only undeveloped portion of the Snake River below Brownlee.

Hydrology

Snake River flows near Clarkston (river mile 134) averaged about 49,000 cfs over the past 51 years. Flows at Weiser (river mile 351) averaged 17,700 cfs over about the same period. Tributary inflow or consumptive water diversions between Weiser and the High Mountain Sheep reach are insignificant, and measurements at the Weiser gage are indicative of total runoff available at the Middle Snake Project area. Although average flows at the project site approximate those at Weiser, the timing of flows are different because of regulation in Brownlee Reservoir and operation of Brownlee, Oxbow, and Hells Canyon Dams for power production. Minimum flows of 5,000 cfs are established for passage at Hells Canyon Dam to meet downstream navigation requirements. Flows passing Hells Canyon Dam under predicted 1985 conditions, shown in Appendix A, Table A-1, have been computed by Bonneville Power Administra-

TABLE 2
HYDROELECTRIC PROJECTS
SNAKE RIVER BASIN
WASHINGTON, OREGON, AND IDAHO

State	Project	River	River Mile	Owner	Drainage Area (sq mi)	Power Storage Capacity (1,000 ac-ft)	Gross Head (ft)	Installed Capacity (kw)	Average Annual Generation (million kwh)
				Existing Projects					
Wash.	Ice Harbor	Snake	9.7	Corps of Engineers	100,000	Pondage	103	270,000	2,138
Idaho	Lewiston	Clearwater	4.6	Wash. Water Pwr. Co.	9,640	Pondage	36	10,000	81
Oregon	Hells Canyon	Snake	247.0	Idaho Power Co.	73,300	12	221	360,000	1,857
Oregon	Oxbow	Snake	273.0	Idaho Power Co.	72,800	Pondage	120	190,000	1,148
Idaho	Brownlee	Snake	285.0	Idaho Power Co.	72,500	980	272	360,000	2,470
				Projects Under Construction					
Wash.	Lo. Monumental	Snake	41.6	Corps of Engineers	108,500	Pondage	103	405,000	2,637
Wash.	Little Goose	Snake	70.3	Corps of Engineers	101,900	Pondage	101	405,000	2,523
Wash.	Lower Granite	Snake	107.5	Corps of Engineers	103,500	Pondage	105	405,000	2,541
Idaho	Dworshak	N.Fk.Clearwater	40.5-1.9	Corps of Engineers	2,640	2,000	630	400,000	1,939
				Authorized Projects					
Idaho	Asotin	Snake	146.8	Corps of Engineers	93,100	13	105	340,000	2,032

Data Source: FPC Planning Status Report, 1967

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tion for their power studies.

Consumptive use of surface and subsurface Snake River Basin waters for irrigation purposes has increased tremendously since the first irrigation began about 1880. Almost all development, estimated at 3.5 million acres in 1965, has taken place in the upper basin, depleting flows passing Weiser to the lower basin. This trend is expected to continue, further depleting flows entering the lower basin.

Quality of Water Available

The water quality analyses presented in this section are based primarily on: (1) data collected over the past several years at four regular sampling stations--two operated by the U. S. Geological Survey and two by the FWPCA--on the lower Snake, (2) data collected by the FWPCA in 1963 during water quality surveys of the Clearwater and Snake Rivers near Lewiston, and (3) data collected by the FWPCA in 1965 and 1966 during surveys of the Snake River near Brownlee Dam. Miscellaneous water quality data collected by the USGS, FWPCA, and Bureau of Commercial Fisheries (BCF) between Weiser and Oxbow Dam (a river-run development just downstream from Brownlee) was also utilized. Appendix B contains several tables summarizing the basic data obtained from the sources mentioned above.

The appended water quality data reveals that, in general, the chemical quality of the lower Snake River is relatively high; major quality problems are associated with high temperatures and excessive algal productivity. Unsatisfactory dissolved oxygen concentrations in reaches have been reported, however.

Dissolved oxygen concentrations near saturation values are common throughout most of the lower river, although unsatisfactory DO concentrations have been measured in Brownlee and Oxbow Reservoirs, and downstream from Oxbow Dam. A DO depression also occurs below the Lewiston area waste discharges, but this condition should improve somewhat when State pollution abatement plans are implemented. Diurnal variations are quite pronounced, indicating photosynthetic activity by algae.

Data collected in Oxbow Reservoir by the Bureau of Commercial Fisheries in August, 1961 indicated DO concentrations from 4.4 to 5.4 mg/l (50 to 60 percent saturation) existed at depths of 0 to 50 feet. Total DO depletion was reported at bottom depths of 115 feet. August to October, 1963 BCF data indicated DO concentrations of only 4 to 6 mg/l below Oxbow Dam while DO concentrations above Brownlee Reservoir were 6 to 10 mg/l. These findings are corroborated by FWPCA data collected in 1965 and 1966 at Weiser (above Brownlee) and below Oxbow Dam. The FWPCA data, summarized in Appendix B, Table B-5, shows DO concentrations below Oxbow Dam are commonly 5.5 to 6.5 mg/l, or only about 65 percent of saturation. The influence of Brownlee and Oxbow Reservoirs on the DO resource is readily apparent when comparing data collected above Brownlee to that collected below Oxbow.

Dissolved-oxygen-deficient water in lower levels of Brownlee and Oxbow Reservoirs, due primarily to the oxygen demanded by decompsoing algae, is passed downstream through low level outlets. The DO is completely replenished between Oxbow and Lewiston, however, attesting to the excellent reaeration capabilities of the intervening stream. DO concentrations above Lewiston and below Oxbow are shown in Appendix B,

Tables B-1 and B-5. These data do not reflect the influence of Hells Canyon Dam (a recently completed "river-run" hydroelectric development downstream from Oxbow). Hells Canyon Reservoir inundates some 25 miles of fast flowing stream and, assuming DO levels are not significantly changed within the reservoir, conditions which existed at Oxbow Dam in the past are expected to shift to below Hells Canyon Dam under present conditions. The impact on DO at Clarkston is expected to be slight since over 100 miles of open stream still remains to replenish the oxygen. Routine water quality sampling at the USGS station at Clarkston over the next year should clearly show any changes in DO content caused by Hells Canyon Dam.

Except for the reach discussed above, dissolved oxygen concentrations in lower Snake are consistently above minimum levels called for by State standards and are satisfactory to accommodate all expected water uses.

Biochemical oxygen demand (BOD) is a measure of the amount of dissolved oxygen consumed in biochemical stabilization of organic matter present in a sample. Practically all surface waters display some background BOD due to decaying vegetation, contamination by animals, etc. A demand of 1 mg/l is not uncommon, even in areas where man-made pollution is absent. Data gathered during the 1963 survey (see Appendix B, Table B-4) reveals that BOD concentrations averaging about 2.5 mg/l exist in the Snake River above Clarkston. Since the nearest source of waste loading is over 200 miles upstream, these BOD levels are much higher than would be expected. Significant algal blooms occur in the stream and Brownlee Reservoir, however, and the higher demands are due to die-off and decomposition of algal cells. These above-normal BOD concentrations have little effect on DO levels under free flowing stream conditions, but can be expected to cause problems when the entire lower Snake becomes slack water.

Basic nutrient (phosphates and nitrates) concentrations are high throughout the Snake during most of the year. Phosphate concentrations normally exceed the 0.03 mg/l generally considered the threshold level for promotion of nuisance aquatic plant growth. Nitrate concentrations are not excessive at all times, but are usually above the threshold value (0.30 mg/l measured as nitrogen) at which excessive algal productivity can be expected.

In recent years, floating aquatic slimes, stimulated by these high nutrient concentrations, have appeared in the Snake River during low spring flow periods. The unsightly water weeds were prevalent from Oxbow Dam to the mouth of the Clearwater; restricting boating, sport fishing, and other recreational uses of the Snake River above Lewiston.

Except for algal productivity, temperature is probably the most restrictive water quality indicator, in terms of uses affected, in the lower Snake Basin. Present and projected streamflows (minimum 5,000 cfs) are adequate to assimilate existing organic loads and at the same time meet the minimum DO standards. Assuming adequate disinfection of wastes, dysenteric and pathogenic bacteria need not be a problem; and with satisfactory policing and control of toxic wastes, excessive concentrations of deleterious materials can be kept from the stream. However, high water temperatures approaching ambient levels near the mouth in late summer, and elevated levels in spawning reaches during the fall, seriously affect the Snake River salmonid fishery, which is a significant portion of the Columbia River fishery.

Existing water temperature conditions at Ice Harbor Dam (at the confluence with Columbia River) are governed by releases from Brownlee

Reservoir, and influenced significantly by temperatures of the Salmon and Clearwater Rivers. Temperature effects of the Grande Ronde River, another major tributary of the lower Snake River, are reportedly minor. 1967 data from USGS "Weekly Runoff Reports" show that temperature reductions through Brownlee Reservoir of 10° F are common during July and August (see Table B-6). Fall temperatures, however, are increased by about 6° F to 8° F. These conditions are a result of low level releases from Brownlee Reservoir which stratifies significantly during the summer months. Depletion of cold water reserves during summer months cause the adverse increases in release temperature during the fall months.

The temperatures of the Snake River at Ice Harbor Dam are reportedly lower than at Oxbow Dam for all but two months of the year because of cool water temperatures from the unregulated Salmon and Clearwater Rivers. The influence of these major tributaries can be readily seen by reference to Table B-6. Their low temperatures and large discharges have a depressing effect on Snake River temperatures at their respective confluences. Note, however, that September-October temperatures at Ice Harbor Dam of 65 to 70° F have been experienced because of the high temperature releases from Brownlee Reservoir and relatively smaller influence of the Salmon and Clearwater Rivers during these months. It is estimated that the interaction of Brownlee Reservoir releases with tributary inflows has, in an average year, reduced the maximum summer temperatures at the mouth of the Snake River from 81° F to 76° F; reduced maximum month mean temperatures from 74° F to 71° F; and moved the month of maximum temperature from July to August.

Future water temperatures of the lower Snake River will be further modified by completion of the Dworshak Dam (under construction) on the North Fork Clearwater River. Other projects, both proposed and under construction, will exert only minor influences. Dr. Wayne Burt[1/] has estimated that releases from Dworshak Reservoir, at the design penstock elevations, will reduce July temperatures of the Clearwater River at its mouth by 4° F to 9° F. Unfortunately, the October-November temperatures will be adversely increased by about the same amount.

In summary, present water quality deficiencies in lower Snake Basin are associated with: (1) high water temperatures, (2) nuisance level aquatic plant growth stimulated by excessive nutrient concentrations, and (3) depressed dissolved oxygen concentrations in and below impounding reservoirs. Sanitary and public health conditions below Lewiston-Clarkston area waste discharges can be alleviated by higher and more complete treatment.

The organic or BOD content of water in lower Snake River is expected to undergo little change due to expanded population and industrial growth in the Lewiston-Clarkston areas. Secondary waste treatment (projected 2020 treated load 190,000 PE), with expected minimum navigation flows (5,000 cfs), will control dissolved oxygen to the established standard levels. Additional nutrients will be added to the river, however, via the treated waste effluent. The economic base study and forecast and the waste projection data utilized in this determination are attached as Appendix C and D, respectively.

1/ Temperature prediction reports on High Mountain Sheep project.

Water temperature and nuisance aquatic growths will be of continued major concern to uses of lower Snake River for fisheries, recreation and municipal and industrial water supply.

VI. WATER USES AND QUALITY EFFECTS

Need for Control

General

Surface waters of the Lower Snake are presently used for irrigation, recreation, fish and wildlife, municipal and industrial supply, and power generation purposes. Upon completion of the locks at the four dams on the lower river, slack water navigation will be possible from the mouth of the Snake to Lewiston. Water quality affects power generation and navigational uses very little; therefore, these two uses need not be considered further from a quality standpoint, except as management of the resource for these purposes affects the quality of water available for other uses.

Irrigation

Irrigation in the lower basin is limited to occasional narrow strips of bench and bottom lands along the mainstem Snake and its major tributaries. Upper Salmon River flows are depleted by irrigation diversions at times; but, in general, use of lower Snake Basin surface water for irrigation purposes has little effect on either flows or quality of lower Snake River.

Municipal and Industrial Supply

The largest single diversion of lower basin surface water for municipal and industrial (M&I) supply takes place at Lewiston, where the city's supply is withdrawn from the lower Clearwater River. No M&I water is withdrawn from the Snake River downstream from Lewiston, and M&I use from tributary streams is minor. Diversion requirements will increase as the Lewiston population grows, and a large portion of the future M&I

need, projected to reach 223,800 acre-feet by the year 2020, is likely to come from this source.

Chemical quality of mainstem Snake River water is satisfactory for M&I use and, with simple disinfection, bacteriological quality would be acceptable. The water would require extensive treatment to correct physical deficiencies, however, which would cause potential users to exhaust alternative supplies before resorting to its use. Taste, odor and clogging filter problems caused by algal blooms, and turbidity which occurs during high flow periods are all factors contributing to the difficulty in treating this water.

Recreation

Basin waters are used for a variety of recreational activities. Public bathing beaches at Lewiston and Clarkston and several attractive beaches downstream are used for swimming. Pleasure boating and water skiing are popular activities where waters are deep and wide near Lewiston. The Salmon, Clearwater, and Grande Ronde Rivers and their tributaries constitute important outdoor recreation resources; and legislation to define portions of each of these as wild rivers has been proposed.

With completion of the five Lower Snake dams, and development of recreational facilities along the reservoirs, extensive recreational use of these pool and adjacent areas, including boating, swimming, water skiing, camping, and picnicking, can be expected. Heavy recreational use of Lower Granite Reservoir by residents of the Lewiston-Clarkston area is expected, and it would not be unreasonable to assume utilization of both Little Goose and Lower Granite Reservoirs by residents of the Pullman-Moscow area. These areas are readily accessible to the entire Lower Snake Basin population, which is projected to approach 350,000 persons by 2020.

Fisheries

Estimates of the numbers of salmon and steelhead entering the Snake River have been made by the Bureau of Commercial Fisheries. About 47 percent of all species of anadromous fish passing McNary enter the Snake River system (305,700 fish annually).

A total of 65,700 fall chinook spawn in the mainstem of the Snake River, with 44,500 passing above the High Mountain Sheep damsite. Hells Canyon Dam facilities collect 12,200 of these fish for artificial propagation. Between Lower Monumental damsite and High Mountain Sheep site, 21,200 fall chinook spawn in the main river. In addition, 600 fall chinook (300 to each stream) spawn in the Clearwater and Imnaha Rivers. Other fish spawning in the Snake Basin number 239,400, of which spring and summer chinook and steelhead are the most numerous. They distribute primarily to the Salmon, Imnaha, Grande Ronde and Clearwater Rivers. Included in this total are 8,200 spring-summer chinook and steelhead collected at Hells Canyon Dam for transport to the Salmon River.

The U. S. Fish and Wildlife Service estimates that the Snake River anadromous fishery above China Gardens damsite contributes over 8,000,000 pounds annually to the commercial catch, and about 2,700,000 angler-days annually to sports fishing. The fishery above China Gardens damsite represents only about 38 percent of the entire Snake River fishery, but because most chinook salmon use this reach, it is estimated to contribute about 80 percent of the commercial catch and 64 percent of the sports fishery.

Adult salmon and steelhead enter the Snake River from April through November with peak periods of movement in April, June and September.

Spawning of fall chinook occurs in the mainstem Snake River from October into December. The eggs and fry remain in the gravel for a period up to five months before emerging. Fall chinook rear in the main stream about three months before migrating to the ocean. Other species, which spawn in the tributary streams, rear in the streams for a year before their migration. A significant migration from the tributaries to the Snake River occurs from September to November, but

the peak migration takes place from March through July. Table 3 shows anadromous fish activities, by reach and period, in the Snake River Basin.

Perhaps the greatest threat to salmonid fish in the Snake River system, other than physical barriers which block and/or retard spawning fish runs, is high water temperatures. Dissolved nitrogen, which is harmful to fish at supersaturated concentrations, is a potential problem that must be considered.

High water temperatures lower the ability of juvenile salmonids to escape predators while increasing the predator species' activities. Fish delayed in their migration by high temperatures are exposed to poisonous substances of increased toxicity and pathogenic bacteria are made more virulent by the temperature. Reduced egg viability also results.

Brett (1952, 1959) reported that chinook salmon were the most tolerant of the five Pacific salmon species to high temperatures and, given slow acclimation, would survive with temperatures as high as 75° F; but died when exposed to slightly higher temperatures. The total adverse effects of high temperatures cannot be evaluated in a simple experiment, however, and the 75° F temperature would very likely have produced mortalities under natural conditions; due to the cumulative harmful effects of other factors found in the natural environment. Leitritz (1962) points out that a progressive loss in egg viability results when salmon spawners are subjected to temperatures above 56° F within a six month period prior to spawning.

Probably all fishes are continuously exposed to the spectrum of their common pathogens. Most pathogens are not a problem, however, until

some factor weakens the fish, rendering it susceptible to disease, or increases the virulence of the pathogen, which subsequently overcomes the host's normal resistance. In both instances, high water temperatures are detrimental; they reduce resistance of fish to disease and they increase the virulence of some disease producing bacteria. In the Columbia River system, one of the most important diseases is Columnaris, caused by Chondroccus columnaris, a myxo bacterium which is normally highly pathogenic in a warm water environment.

High water temperatures (70-80° F) in mainstem Snake during the summer and fall months stress all salmonid fishes, but have a particularly adverse effect on upstream migrants which have already been subjected to above-desirable temperatures and supersaturated nitrogen concentrations in the Columbia River. These high temperatures blocked upstream migrants at the mouth of the Snake for several weeks in 1967.

Recent surveys by the Bureau of Commercial Fisheries (BCF), Seattle, Washington show much of the Columbia River below Coulee Dam contains supersaturated concentrations of dissolved nitrogen. Studies by the BCF indicate fish mortalities in these waters have occurred due to gas-bubble disease, which is caused by gas bubbles forming in the blood and tissues of fish. These bubbles appear to result from the process of excess dissolved nitrogen reverting to the gaseous state within the circulatory system of the fish.

Marked increases in dissolved nitrogen concentrations have been measured below dams during spilling periods, indicating spillways may be responsible for these supersaturated levels. With construction of additional dams on the Snake, and with the accompanying pool areas in

which supersaturated nitrogen concentrations would be slow in equilibrating with the atmosphere, excessive dissolved nitrogen could also become a problem in the mainstem Snake. The danger would be particularly high during times when spillways are operating.

VII. FACTORS AFFFCTING WATER QUALITY

General

The construction of any dam can be expected to materially alter the limnological characteristics of a river. In attempting to predict the character and extent of these changes, one must look to comparable reservoir developments to see how they affected the limnology of the streams on which they were constructed. A vast amount of knowledge on natural lakes has been accumulated; but, because of the diverse characteristics of lakes and reservoirs, not all of this knowledge can be applied directly to problems on reservoirs. In fact, Neel (Impact of Reservoirs, 1966), states: "They (reservoirs) frequently appear to violate every principle deemed proper and appropriate for bodies of standing water." The major difference between reservoirs and lakes, which may account for the diverse characteristics, is the depth of water discharge, which is below the surface in most reservoirs; whereas most lake outlets draw from surface waters.

The U. S. Fish and Wildlife Service and the FWPCA have conducted water quality studies on Brownlee Reservoir in recent years, and a moderate amount of data on its limnology is available. This reservoir, located some 70 miles upstream from the Appaloosa site, is considered the best available source of information to use in predicting the effects of a reservoir in the Middle Snake development reach.

Use of Brownlee Reservoir for predictive purposes is complicated by the fact that its maximum depth is only about one-half that being

investigated for Appaloosa or High Mountain Sheep sites, and it has a single-depth discharge. The latter dams would have multiple-depth discharge capabilities. Nevertheless, reservoir development at Appaloosa or High Mountain Sheep could be expected to result in quality characteristics similar to Brownlee, and for this reason the quality characteristics of this reservoir were used as a basis for predicting impoundment effects on water quality.

Reservoir Effects

Algae

As discussed previously in the section on present water quality, the Snake River contains high nutrient concentrations throughout most of its length. Phosphate and nitrate concentrations are usually well above the threshold limits for the promotion of nuisance level aquatic plant growth. Kari and Galloway (PHS Survey) report "great algal blooms in most areas" between Adrian, Oregon and Weiser, Idaho on Aug. 22-23, 1961. They also state: "The Snake River carried an exceptionally heavy load of algae in suspension. Dominant types at the time of the survey were Anabaena, Pediastrum, Spirogyra, Aphanizomenon, Staurastrum, and Anacystis". (Three of these types are blue-greens and indicators of nutrient-rich waters). They further mention that "the addition of agricultural fertilizers and other nutrients via irrigation return waters is suspected...". Ebel and Koski (Bureau of Commercial Fisheries, 1967) report that "the large phytoplankton blooms in Brownlee Reservoir throughout the summer indicated that high turbidity did not seriously hinder primary production at the surface". Based on the foregoing evidence of algal production in Snake River waters, it would be expected that High

Mountain Sheep Reservoir (or any of the alternatives) would likewise produce abundant algal growths. These algal growths would very likely occur to such a degree that esthetic qualities of reservoir surface areas would, at times, become unattractive to the public for recreation and fishing purposes.

Dissolved Oxygen

Reservoirs rich in algae produce a continuous "rain" of dead or dying algal cells which settle into the hypolimnetic (lower level) waters. This material as it decomposes has a high oxygen demand which, together with additional inflow material of organic origin, rapidly depletes the lower stratum dissolved oxygen supply. Because there is no photosynthetic production of oxygen at this depth and because atmospheric reaeration cannot take place, there is no opportunity for oxygen replenishment.

Studies on Brownlee Reservoir have borne out this depletion phenomenon. Pronounced temperature stratification was observed during the late spring, summer, and fall periods resulting in a well-defined epilimnion, thermocline, and hypolimnion. Stratification of dissolved oxygen accompanied this condition. At times, the dissolved oxygen content of the lower hypolimnetic waters dropped to non-detectable levels. A reservoir in the Middle Snake impoundment reach would be expected to act similarly. Because of greater depths, and greater volumes of water at these depths, the problem of low dissolved oxygen would be even more severe than at Brownlee.

Dissolved oxygen content of mixed discharges from multi-level outlets would be only 50 percent or less of saturation concentrations during extended periods during late summer and fall months. Because of high discharges required to meet power peaking requirements, artificial aera-

tion within the high dam, either mechanically or by direct injection of air or pure oxygen, to raise concentrations to required levels (75 percent of saturation at seasonal low; 100 percent of saturation during spawning in the fall) would not be feasible. However, natural turbulent reaeration and/or artificial aeration in a re-regulatory reservoir could be utilized to raise deficient DO concentrations in release waters to required levels.

Dissolved Nitrogen

Supersaturated dissolved nitrogen concentrations in much of the Columbia River below Coulee Dam have been measured in recent surveys by the Bureau of Commercial Fisheries. Examination of a profile of dissolved nitrogen percent saturation versus river mile discloses marked increases in dissolved nitrogen content occur below dams during spilling periods.

Westgard (1964) discusses supersaturated dissolved nitrogen effects on fish in a report on tests conducted at McNary Spawning Channel in 1962. At McNary, dissolved nitrogen concentrations increased from 100 percent to 119 percent of saturation in water passing over a weir in a drop structure. These measurements indicate that the air entrained in water cascading over the weir was forced into solution by a 16-foot pressure head that existed at the bottom of the drop structure. (This increase is equivalent to about 7 pounds per square inch, or one-half of normal atmospheric pressure. Theoretically, ignoring the effects of water vapor pressures, gas saturation values at this depth would be about 150 percent of the normal values at the water surface.) Adult salmon held in the supersaturated waters suffered extensive mortality due to gas-bubble disease.

Conditions causing excess dissolved nitrogen content could be duplicated in a spillway or aeration facility incorporated into a development on middle Snake River, and these facilities should be carefully designed to avoid this problem. Aeration facilities, particularly those injecting air under pressure into lower pool areas, would be expected to contribute to supersaturated nitrogen levels.

Temperature

Detailed studies have been conducted to evaluate project capability to control temperatures of lower Snake River waters. Predictions of reservoir and downstream water temperatures to be expected under various weather, streamflow, and reservoir operating conditions have been made. These predictions are presented in Chapter VIII.

Downstream Effects

Eutrophic reservoirs under stratified conditions produce biochemical and other degradation changes in hypolimnetic waters. Although a stratified anaerobic hypolimnion will not directly cause unfavorable esthetic conditions within the reservoir, such waters when released from this lower layer may cause undesirable oxygen and algal regrowth conditions downstream. Downstream oxygen problems may be minimized, however, by incorporating features in the outlet facilities to aerate the released water or be optimized with releases for temperature control (with or without aeration) by simultaneous water withdrawals from several levels.

Algal regrowth downstream or throughout a series of reservoirs is associated with the cyclic availability of phosphorous in reservoir strata. Symons, Weibel and Robeck (1964) state: "Although the reactions involving phosphorous are known, the behavior of phosphorous in a specific impoundment is not predictable". Also, Neel (1966) states: "If surface releases join hypolimnetic waters coming from power or other units..., plankton often displays an immediate proliferation and frequently reaches densities exceeding those developed in the reservoir." When surface waters are drawn from the reservoir, the cells therein may not survive. However, the nutrients contained in the cells will be released, thus transporting nutrients downstream and increasing the possibility of algal growth. Neel (1967) believes that the natural tendency would be for productivity to increase rather than decrease through a series of reservoirs. Nutrient increases due to nitrogen-fixation by certain algae may be responsible.

The cyclic behavior of nutrient availability in Middle Snake River appears to follow patterns observed by other workers in the field. Data on Brownlee indicates that phosphorous coming into the reservoir is rapidly incorporated not only by algal cells, but also by zooplankton and higher aquatic plants in the epilimnion. Under stratified conditions phosphate uptake by living matter places a large proportion of the nutrient in cellular form thus leaving only a fraction in the water itself. Although not specifically demonstrated at Brownlee, this cellular material eventually dies due to unfavorable growing conditions and, except for some precipitation to the reservoir bottom, would release most of the phosphorous back into the water.

Summary

To summarize, a deep reservoir on the middle Snake River, operated as proposed in preliminary plans, is expected to stratify. The hypolimnetic waters of the reservoir would become low in dissolved oxygen during periods of stratification, due mainly to algal cell decomposition. Abundant growths of algae would also occur in epilimnetic waters during these periods, possibly to the detriment of recreational activities. Release waters would contain nutrient concentrations high enough to support abundant algal growths downstream. Excess dissolved nitrogen concentrations could be introduced into release waters through improperly operated or designed spillways or reaeration facilities.

VIII. TEMPERATURE EFFECTS

Temperatures of Release Waters

Advantage can be taken of stratified reservoir temperatures to the benefit of downstream uses. Problems with low dissolved oxygen, however, must be overcome in order to realize these temperature benefits.

Potentials for management of lower Snake River temperatures through regulation of Appaloosa Reservoir have been computed for average weather and flow variability conditions using two operating schedules; one specifically for temperature control, and the other incidental to primary operation for power. Also, the potential has been computed for somewhat critical weather and flow conditions, operating the reservoir exclusively for maximum power production. Temperature objectives for the river downstream from the middle Snake River development area are discussed in detail in Chapter IX. Monthly criteria for reservoir release temperatures are tabulated in Table 4.

Appaloosa Reservoir would contain a considerable volume of cool water, which, if properly released, could exert significant improvements in temperature conditions downstream.

The reservoir isotherms predicted for each condition referred to above are plotted in Figures 1, 2, and 3. Predicted temperatures of release water obtainable under each situation are tabulated in Table 4.

Figure 1 shows predicted Appaloosa Reservoir isotherms for a year of median thermal conditions (i.e., average weather) and relatively low annual yield (9,600,000 acre-feet), utilizing 500,000 acre-feet (AF)

of storage primarily for temperature control during July and August. Predicted isotherms for the same thermal and yield conditions as Figure 1 ,,operating the reservoir for maximum power production with no storage used specifically for temperature control,are plotted on Figure 2 . The isotherm patterns are influenced by surface heating (or cooling), seasonal variations of inflow quantities and temperatures, and the turbine intake combinations selected to obtain the desired discharge temperatures. The major difference between Figures 1 and 2 is the effect of the 500,000 AF drawdown (Figure 1) for temperature control during July and August. For both computations, cold water was reserved for withdrawal during the late fall and early winter months. This regulation would be somewhat more successful under the power production flow pattern than the specific temperature release pattern, although cold water reserves would be small by November 1 in both cases. For successful regulation, the reservoir should be completely mixed (isothermal) by March 1 of each year.

Reservoir isotherm computations for 1-in-10 year thermal conditions (Figure 3) utilize relatively high inflows,operating for maximum flood control power production. Cool winter flows must be evacuated to provide space for large volumes of warmer water that enter the reservoir in late spring under the conditions of this computation. Under these conditions, the reserves of cold water would be essentially depleted by the first of November. Consequently, in order to meet the November release temperature objective, cold inflows, then available, would require routing along the bottom of the reservoir as thermal underflows.

The regulated discharge temperatures of Appaloosa Reservoir releases under the three situations discussed above are summarized for comparison with the recommended temperatures in Table 4. Temperatures of reservoir inflows for median, and 1-in-10 year thermal, conditions are also listed. It is apparent from Table 4 that recommended discharge temperatures can be achieved for both median and relatively critical conditions of weather and inflows. Moreover, it is apparent that these temperatures can be obtained equally well under both patterns of flow regulation. At no time are the predicted discharge temperatures more than 5° F higher (or lower) than the recommended temperatures.

It is evident from these studies that the "margin of safety" relative to cold water reserves for temperature regulation in the fall will be minimal during average conditions of weather and inflow; and will be non-existent during critical years. Under these conditions, in-line pump-back storage operations, if otherwise justified, must necessarily be limited to the months of January and February. If operated at other times, the development of stratification required to preserve the identity of late fall and winter inflows in the reservoir would be inhibited. Increases in discharge temperatures of at least 5° F could be expected under pump-back storage conditions. Also, a reservoir appreciably smaller than that studied at the Appaloosa site (2.41 million AF storage capacity) would not be capable of providing downstream temperature control because of limited cool water pool volume. This conclusion automatically eliminates the Pleasant Valley site (1.05 million AF storage capacity) from consideration for water temperature regulation. The High Mountain Sheep alternatives would have the same potential for downstream

temperature control as Appaloosa. However, extreme fluctuations in flows due to power peaking operations at High Mountain Sheep without a re-regulatory reservoir could cause undesirable,wide temperature fluctuations downstream.

Downstream Water Temperatures

The predicted July and August discharge temperatures from each of the existing and proposed downstream reservoirs are listed in Table 5 for a year of median thermal conditions. Also listed for comparison are the estimated "no project" temperatures. Predicted downstream temperatures are based upon the mixed discharge temperatures from Appaloosa Reservoir tabulated in Table 4 . Several conclusions are immediately apparent from Table 5 .

First, the "no project" temperatures, estimated from existing thermograph records for an average weather year, will be several degrees higher than required for enhancement of the anadromous fishery. The upper limit of temperature established for this reach is 68° F.

Second, the mean temperatures for July and August at Ice Harbor Dam can be maintained at or below the objective of 68° F for both patterns of flow regulation, presuming the development of thermal underflows in all of the reservoirs except China Gardens. The presumption that thermal underflows will develop is based on current knowledge of intermediate depth reservoir hydraulic characteristics. If thermal underflows due to downstream reservoir operations cannot be maintained, predicted temperatures at Ice Harbor Dam will average over 70° F during August of an average weather year. Comparable temperatures at Ice Harbor Dam for a

relatively warm year will be about 1° F higher.

Third, the predicted maximum temperatures during July and August of an average weather year will be about 70 to 71° F in the presence of thermal underflows. Without thermal underflows, predicted maximum temperatures will reach 74° F during August. Again, maximum temperatures at Ice Harbor Dam would be about 1° F higher during a relatively warm year.

Fourth, within the range of streamflow and weather conditions selected for these computations, there is no indication of significant temperature difference at Ice Harbor Dam between operations specifically for temperature, or temperatures resulting incidental to power regulation. Within these limits of computation an allocation of 500,000 AF storage for temperature control does not appear warranted. As noted earlier, however, reserves of cold water for release during late fall months under 1985 hydrologic conditions would be minimal during average years, and would be exhausted during critical years of weather and inflows. Also, future streamflow diversion beyond the design year of 1985 for upstream irrigation development can be expected to reduce summer inflows to an even greater extent. Although cold water reserves under 1985 conditions could be proportionately increased by filling the reservoir from March 1 to April 15 and "passing through" the warmer spring inflows of April 15 to May 30, shortages of cool water for late season use would become increasingly critical. Presuming that the future inflows were reduced to the minimum of 5,000 cfs stipulated in the Hells Canyon Project FPC license, releases at Appaloosa of at least an additional 4,000 cfs

would be required to achieve downstream temperature objectives. In this case an allocation of 500,000 AF of storage for water quality management would provide a safeguard against future conditions not specifically tested by the above-noted computations. This aspect, however, should be considered in the planning of future upstream irrigation developments.

Discussion

In summary, the investigation of water temperature enhancement potential by regulation at Appaloosa Reservoir has revealed that:

(1) Maximum temperatures in the lower Snake River under "without project" conditions will exceed upper limits established for maintaining the anadromous fishery.

(2) Under the selected computation conditions of inflow, weather, and optimum reservoir level releases, temperature enhancement can be achieved from regulation at Appaloosa Dam. Under similar conditions, with multi-level release capability, the same conclusion would apply to High Mountain Sheep Reservoir. Pleasant Valley Reservoir would not produce a cool water pool large enough to provide significant temperature regulation.

(3) Temperature regulation incidental to exclusive operations for power at either Appaloosa or High Mountain Sheep sites would require re-regulation facilities.

(4) In-line pump-back storage should be limited to the months of January and February.

(5) The achievement of temperature objectives under conditions selected for the computations will be comparable whether operations are

designed primarily for temperature control or maximum power production.

(6) With substantial development of possible upstream irrigation, a storage allocation of 500,000 AF in Appaloosa Reservoir for water temperature regulation would be essential.

(7) Alternative management of water temperature at the Appaloosa site would require construction of a single-purpose reservoir having essentially the same capacity as the proposed reservoir.

Figure 1 Reservoir Regulation Diagram (cont.)

Pressure (10³ psi)
Temperature (°F)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995
Initial Reservoir Pressure
Initial Reservoir Temperature
Saturation Pressure

Figure 2. Reservoir Temperature and Pressure Profiles

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TABLE 4

APPALOOSA RESERVOIR TEMPERATURE REGULATION SUMMARY[1]

Computation Period	Inflow Temps (°F) Median Therm.Cond's	Inflow Temps (°F) 1-in-10 Therm.Cond's	Recommended Discharge Temps (°F)[2]	Computed Discharge Temperatures (°F) Median Therm.Cond's Annual Yield=9.6x10^6 AF[5] Water Quality Flow Regulation[3]	Median Therm.Cond's Annual Yield=9.6x10^6 AF[5] Power Production Flow Regulation[4]	1-in-10 Therm.Cond's Annual Yield=13.5x10^6 AF[6] (Power Production Flow Regulation)[4]
Mar. 1-15	39.9	40.7	43	39.6	39.6	40.4
Mar. 16-30	42.0	42.8	43	40.5	40.5	43.4
Apr. 1-15	48.8	49.6	52	42.5	42.5	45.7
Apr. 16-30	51.0	51.8	52	47.9	47.9	50.1
May 1-15	55.0	55.8	58	54.6	54.6	51.8
May 16-30	57.8	58.7	58	54.2	54.2	58.8
Jun. 1-15	63.2	64.0	62	57.6	57.6	62.4
Jun. 16-30	64.9	65.7	62	58.6	58.6	63.0
Jul. 1-15	66.8	67.6	60	57.0	56.4	59.2
Jul. 16-30	68.0	68.8	60	58.4	58.2	60.6
Aug. 1-15	70.8	71.6	60	58.1	57.7	60.2
Aug. 16-20	71.3	72.1	60	59.4	60.2	58.9
Aug. 20-30	70.8	71.8	60	59.5	56.7	58.9
Sep. 1-10	70.0	70.8	60	57.5	58.6	60.5
Sep. 11-20	69.5	70.3	60	60.4	58.8	60.2
Sep. 21-30	67.6	68.4	60	58.7	60.3	58.6
Oct. 1-10	64.4	65.4	55	55.4	53.9	54.3
Oct. 11-20	61.3	62.1	55	54.1	53.9	54.6
Oct. 21-30	58.2	59.0	55	55.3	55.1	54.1
Nov. 1-10	55.5	56.3	50	49.4	50.1	52.2
Nov. 11-20	52.5	53.3	50	48.3	48.4	50.7
Nov. 21-30	49.8	50.6	50	49.0	49.4	52.5
Dec. 1-10	46.8	47.6	45	48.2	44.8	49.2
Dec. 11-20	45.2	46.0	45	47.2	46.3	47.9
Dec. 21-30	43.5	44.3	45	46.3	45.5	46.3
Jan. 1-10	41.5	42.3	40	44.5	41.7	43.9
Jan. 11-20	40.0	40.8	40	43.2	41.6	43.6
Jan. 21-30	38.9	38.8	40	40.8	41.4	43.6
Feb. 1-10	36.8	37.6	40	42.7	42.3	39.6
Feb. 11-20	36.6	37.4	40	42.2	41.0	43.8
Feb. 21-30	37.6	38.4	40	41.1	40.2	42.2

1/ Based upon input data from Dr. Wayne Burt's temperature prediction reports on High Mountain Sheep project.

2/ Established by fisheries agencies.

3/ Includes allocated storage for low flow augmentation.

4/ Flow regulation restricted to power production and flood control.

5/ Relatively dry year.

6/ Relatively wet year.

TABLE 5

July - August Lower Snake River Water Temperatures (^{o}F) 1/

for Median Thermal Conditions; Annual Yield at Appaloosa = 9.6×10^{6} AF

	July										August								
			Flow Regulation for Water Quality 3/				Flow Regulation for Power Production 4/						Flow Regulation for Water Quality 3/				Flow Regulation for Power Produc		
	"No-Project" Temp's.		With Therm. Under-flows		Without Therm. Under-flows		With Therm. Under-flows		Without Therm. Under-flows		"No-Project" Temp's.		With Therm. Under-flows		Without Therm. Under-flows		With Therm. Under-flows		With The Unde flo
	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max
Appaloosa 2/	68	67	58	58	58	58	57	57	57	57	72	71	59	59	59	59	58	58	58
China Gardens	69	67	59	58	59	58	59	58	59	58	72	71	60	60	60	60	59	59	59
Asotin	70	68	61	60	61	60	61	60	61	60	73	71	62	61	63	60	61	60	63
Lower Granite	70	69	62	62	63	63	62	62	63	63	74	72	64	63	67	65	64	63	68
Little Goose	72	69	65	63	67	64	65	63	67	64	75	72	67	65	70	68	67	65	71
Lower Monumental	74	70	68	65	70	66	68	65	70	66	76	73	69	67	72	70	69	67	73
Ice Harbor	76	70	71	65	72	67	71	65	73	67	76	73	70	68	74	71	70	68	74

1/ Mixed discharge temp's. from each project dam.
2/ Re-regulation dam discharge.
3/ Utilizes 500,000 AF for flow augmentation during July-A
4/ No flow augmentation for water quality.

IX. MEANS OF CONTROLLING WATER QUALITY

Water Quality Criteria

Standards

To provide a basis for water pollution control programs and to comply with Section 10 of the Federal Water Pollution Act, as amended, the States of Idaho, Oregon and Washington have established standards of quality for Snake River waters (allowable concentrations of coliform bacteria, hydrogen ion, and dissolved oxygen; and maximum allowable temperatures, are tabulated in Table 6). These standards are established in conformance with present and potential water uses of Snake River, which in all three States are: domestic, industrial, and agricultural water supply; livestock watering; anadromous fish passing, spawning, and rearing; resident fishery; hunting and wildlife; and water skiing, swimming, pleasure boating, and aesthetic enjoyment. In addition, Idaho and Washington have designated the lower Snake as a navigational stream.

The Secretary of Interior has approved the standards established by the three States, and the criteria presented in these standards now governs the FWPCA in administering the Federal Water Pollution Control Act in the lower Snake Basin.

The standards state that "No wastes will be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause in these waters: "--violations of criteria set for water quality indicators. Constructing and operating a dam, or dams, on the middle Snake River is considered an "activity" covered by the standards and, as such, must comply with the minimum quality criteria

TABLE 6

STANDARDS OF QUALITY FOR SNAKE RIVER WATERS
(Established by the States of Oregon, Idaho and Washington)

	Coliform Bacteria (maximum allowable, where associated with fecal sources)	Hydrogen Ion Concentrations (pH) (allowable range)	Dissolved Oxygen (DO) (minimum allowable concentrations)	Temperatures (maximum allowable
Idaho (river miles 139 to 247)	Average of 1000 organisms/100 ml; 2400 organisms/100 ml in 20% of samples. Between river miles 139 and 170, average of 240 organisms/100 ml.	7.0 to 9.0 (Induced variation limited to 0.5 pH unit).	75% saturation at seasonal low; 100% saturation in spawning areas during spawning, hatching and fry stages of salmonid fishes.	68° F (2° F increas when river temperatures are 66° or less)
Oregon (river miles 176.0 to 407.3)	Average of 1000organisms/100 ml; 2400 organisms/100 ml in 20% of samples.	7.0 to 9.0	75% saturation at seasonal low; 95% saturation in spawning areas during spawning, hatching and fry stages of salmonid fishes.	70° F (2° F increas when river temperatures are 68° F or less)
Washington (river mile 0.0 to 172.0)	Median of 240 organisms/100 ml; 1000 organisms/100 ml in 20% of samples.	6.5 to 8.5 (Induced variation limited to 0.25 units).	8.0 mg/l	68° F (when less than 68° F the permissive increase, "t", is limited by the relationship t=100/(T-15); where "T" represents the resulting water temperature)

established in the standards; at least to the extent these criteria were met before construction. It should be kept in mind when applying these criteria, however, that they are not to be construed as an invitation to degrade existing quality, but that the highest and best practicable standards will be maintained at all times.

Criteria established by the States are based on meeting quality requirements for all expected water uses in the Basin and, therefore, have been adopted as minimum levels of acceptable quality for water released from a reservoir on Middle Snake River.

Other Criteria

In addition, to the standards shown in Table 6 , basic nutrient (phosphates and nitrates) and dissolved nitrogen concentrations are of interest. Nutrients, which are vital to growth of weeds, slimes, and other undesirable aquatic plants, should be held below 0.03 mg/l, as phosphate, and 0.30 mg/l as nitrate-nitrogen. Dissolved nitrogen should be limited to 105 percent of saturation. Concentrations above saturation are undesirable, but fish begin to show effects of gas-bubble disease when concentrations exceed 105 percent saturation.

Temperature Criteria

Desirable temperatures of reservoir release water to achieve downstream temperature control for anadromous fishery purposes have been established by the Bureau of Commercial Fisheries, in cooperation with the fish and game agencies of the three States. These criteria, tabulated by month in Table 7 , are designed to maintain temperatures at the

mouth as near standards (68° F) as possible; yet conserve cooler reservoir waters for release in the fall to provide optimum temperatures for spawning in the reach immediately downstream from a development.

TABLE 7
WATER TEMPERATURE OBJECTIVES
FOR RESERVOIR RELEASES

Month	Temperature ° F
October	55
November	50
December	45
January	40
February	40
March	43
April	52
May	58
June	62
July	60
August	60
September	60

Storage and Flow Regulation

An impoundment will, in itself, exert considerable reductions in bacterial numbers due to die-away detention time. Quantity releases would do little, however, to reduce downstream bacteria, nutrients or algal growths. In fact, downstream algal conditions will become worse due to cyclic nutrient regeneration through each successive downstream reservoir. Considerable research on nutrient reduction by algae harvest or other means is in progress. If feasible and economical, these methods

might at some future time be used to advantage in lower Snake Basin. Aquatic plant growths are expected to interfere, in various ways, with most water uses in Snake Basin and, while they are not controllable at present either through flow regulation or other known methods, the possibility of controlling them in a project impoundment at some future date should not be discounted.

Temperature Regulation

Temperature studies (described in Chapter VIII) indicate that, through proper operation of multi-level turbine intakes, the reservoirs proposed at either Appaloosa or High Mountain Sheep sites would have considerable potential to control downstream water temperatures. The temperature objectives developed under the criteria section can be approximated under fairly severe thermal and flow conditions.

Waste Treatment

Sources of pollution in lower Snake Basin are tabulated and discussed in detail in Appendix D. Controllable sources of concern are the cities of Lewiston, Clarkston, and Asotin, two meat packing plants near Clarkston, two food processing plants in Lewiston, and a large pulp and paper mill at Lewiston.

Implementation and enforcement plans developed as a part of the standards established by the States of Idaho and Washington are designed to correct undesirable conditions which may be caused by these waste discharges either at present or in the future. Table 8 shows Idaho's implementation plan for the Lewiston area. Construction of treatment facilities at the pulp and paper mill was commenced in October 1967, and will require about a year to complete. These facilities, which are to

TABLE 8

IDAHO WASTE TREATMENT IMPLEMENTATION PLAN

Source	Receiving Stream	Character of Waste	Present Treatment	Current Treatment Needs	
				Requirement	Completion Date
Lewiston	Clearwater River	Domestic Sewage	Primary	Secondary	1970
Seabrook Farms Inc.	Clearwater River	Pea and Potato Processing	Process Controls	Primary and Connect to City	1970
Smith Foods Inc.	Clearwater River	Pea Processing	Process Controls	Connect to City	1970
Potlatch Forests Inc.	Snake River	Pulp and Paper Mill	Process Controls	Primary	1968

remove about 95 percent of the settleable suspended solids carried in the waste waters, should do much to alleviate conditions associated with sludge deposits in the Snake River. However, the organic, oxygen demanding, content of the wastes from the mill, estimated to be 432,000 population equivalents (PE) in 1965, will be reduced only about 15 to 20 percent by the planned treatment, which means about 350,000 PE will remain to be assimilated by the river.

The Washington implementation plan does not specify control needs by individual waste source, but the regulations which apply to all sources are set forth in the introductory paragraph of the implementation plan. The paragraph states:

> "In section II of this regulation water quality criteria for the interstate and coastal waters of the State, and classifications of said waters, are established. To insure that these criteria and classifications are complied with the Commission shall rely on various implementation and enforcement tools at its disposal. In carrying out this implementation plan, it shall be an unalterable guideline that existing discharges which conflict with the criteria and classifications established by this regulation shall be modified so as to be consistent therewith as expeditiously as is reasonably possible but, in all but the most exceptional cases where even with expedition modifications cannot be attained, no later than five (5) years from the effective date hereof. Further, as part of said guideline, it shall be required that all activities which discharge wastes into the waters of the State or otherwise affect the quality of said waters shall provide all known available and reasonable methods of treatment and control."

Under the Washington plan, all wastes in the Clarkston area will be provided adequate treatment at a time no later than 5 years from the effective date of standards certification. Presumably, this would apply to the two meat packing firms near Clarkston.

With implementation of pollution abatement plans proposed by Idaho and Washington, the waste loads entering the Snake River at Lewiston in 1965 would decrease from an estimated 518,000 PEs to 365,000 PEs. The influence of the waste load discharged from the pulp and paper mill is quite apparent; even with implementation of State plans the overall waste load will decrease only 30 percent. Considering the effects of slack water which will exist in the entire lower Snake River and the growth of waste loads from other sources near Lewiston, these mill wastes will no doubt require additional treatment at some time in the future. Any increased waste discharges due to plant expansion will certainly require secondary or equivalent treatment.

X. ALTERNATIVE DEVELOPMENTS

In preceding chapters, water quality associated with present hydrologic conditions in lower Snake Basin have been documented, and quality influences on present uses have been noted. Water quality objectives, as related to maintaining and/or enhancing water uses, have been developed for pertinent quality indicators and generalities with respect to water uses served at these objective levels have been discussed.

As noted previously, an impoundment in the middle Snake reach would have both detrimental and beneficial effects on water quality. Water management techniques, if properly applied, can alleviate detrimental effects and utilize other effects to considerable advantage; provided that certain facilities and conditions are present. Considerable discussion relating these aspects to the Appaloosa alternative have been made since this alternative provides the completeness of features and conditions needed to achieve optimum management of water quality.

The purpose of this section is to analyze quality effects and control capabilities under individual alternative proposals in such a manner that comparative benefits and damages may be assessed. An evaluation of the water uses affected, and the resulting net beneficial or detrimental effect under each alternative, compared to "without project" conditions, are also presented.

Appaloosa with Re-regulatory Dam at Low Mountain Sheep Site

Temperature

Temperature prediction studies indicate that this alternative,

as proposed, has the capability of providing considerable downstream temperature control. Using multi-level turbine intake facilities, downstream temperature objectives can be approximated under somewhat critical thermal and flow conditions, either with or without 500,000 acre-feet of space allocated specifically for water quality control. With future upstream irrigation depletions, which could utilize as much as one-half of the flows used in the temperature studies, or with critical weather and flow conditions, the 500,000 acre-feet of storage space would be required to meet temperature objectives at some future time. Plans for future irrigation developments should consider this downstream impact.

Algae

Extensive algal blooms are expected to occur on the reservoir surface during stratification periods (July, August, and September). Downstream nutrients levels may be reduced somewhat during this period, but on an annual basis, the reservoir will likely cause a net increase in downstream nutrient levels. Nutrient levels will exceed threshold values for stimulation of nuisance aquatic plant growth throughout the year.

Dissolved Oxygen

Reservoir releases will be low in dissolved oxygen content much of the time. Critical conditions are likely to occur during the fall spawning period, when releases containing an estimated 3-to-4 mg/l of DO must be raised to 100 percent of saturation levels (11 mg/l at 50° F). To accomplish the reaeration of discharges, which would be in the neighborhood of 18,000 cfs during this period, some 750,000 pounds of oxygen per day must be introduced and/or forced into solution.

During non-spawning periods, minimum DO concentrations of 75 percent of saturation would be required. Assuming flows of around 8,000 cfs containing no dissolved oxygen were released during these periods, then about 300,000 pounds of oxygen per day would be required to increase the DO content to the 75 percent of saturation required by State standards.

The re-regulatory reservoir proposed at Appaloosa would be ideally suited to provide this re-oxygenation through a combination of natural turbulent and mechanical reaeration. Under these conditions, it appears the 75 percent of saturation objective can be attained without too much difficulty. However, the 100 percent of dissolved oxygen saturation required during spawning periods would be much more difficult to achieve. Carefully designed and operated aeration and release facilities in the re-regulatory reservoir would be required to even approach this objective.

Since fish collection facilities would be installed below the Appaloosa regulatory dam, no anadromous fish would be present in the re-regulatory reservoir to be harmed by the expected low dissolved oxygen content of these waters. Also, the reservoir would not be accessible to the public because of severe water level fluctuations. Consequently, low dissolved oxygen levels in the re-regulatory reservoir waters would not interfere with water uses; providing the DO content is raised to acceptable levels before discharge to the stream below.

Dissolved Nitrogen

Since air contains roughly 80 percent nitrogen gas, nitrogen concentrations at saturation or above will no doubt exist in waters subjected to aeration by other than surface agitation. If waters con-

taining supersaturated dissolved nitrogen concentrations are released through low level outlets in the re-regulatory dam, then excess dissolved nitrogen could be expected in the stream below. As nitrogen supersaturation in large streams is known to persist for many miles before equilibrating with the atmosphere, this could be as harmful to fish as low dissolved oxygen levels. Aeration methods which would result in minimal nitrogen entrainment should be considered.

Benefits

Controls on temperature achievable with Appaloosa Reservoir can result in considerable fishery enhancement and prevention of future fishery declines. Increased fishery use, as estimated by the U. S. Fish and Wildlife Service, could amount to 11,300 fall chinook, 7,800 spring-summer chinook, and 43,400 steelhead trout annually. Total monetary values would be in the order of 6 million dollars annually. Table 9 shows comparative fishery use for all alternatives analysed.

Little change in water quality affecting downstream recreation is anticipated. Algal blooms at levels detrimental to this use are expected under both "with" and "without project" conditions. Cool water releases would impair some water contact activities, but the net effect should be minor. Profuse algal blooms on the surface of Appaloosa Reservoir will very likely interfere with recreational use of the impoundment during July and August.

Water quality for other water uses, such as M&I water supply, irrigation, power production, and navigation, should not be affected by development of the Appaloosa alternative.

TABLE 9
PREDICTED ANADROMOUS FISH USE
OF THE SNAKE RIVER SYSTEM
UNDER ALTERNATIVE DEVELOPMENT PLANS

Alternative	Numbers of Fish Annually				
	Fall Chinook	Spring-Summer Chinook	Sockeye Salmon	Steelhead Trout	Total
Without Project	66,300	122,200	3,500	113,700	305,700
Appaloosa with Re-Regulatory Dam	77,600	130,000	3,500	157,100	368,200
High Mountain Sheep with Re-Regulatory Dam	17,900	15,200	0	67,700	100,800
High Mountain Sheep without Re-Regulatory Dam	14,300	15,200	0	67,700	97,200
Pleasant Valley with Re-Regulatory Dam	66,300	122,200	3,500	113,700	305,700

DATA SOURCE: U. S. Fish and Wildlife Service

High Mountain Sheep, with a Re-regulatory Dam at the China Gardens Site

General

A deep reservoir at this site would exhibit quality characteristics quite similar to those expected at Appaloosa. Similar control of temperature could be achieved and similar requirements for reaeration and avoidance of nitrogen entrainment would apply. Dissolved oxygen standards in important spawning and passage reaches immediately below the dam, however, may not be attainable.

Dissolved Oxygen

China Gardens site is 16.7 miles downstream from High Mountain Sheep as compared to the 5 mile distance between Appaloosa and its re-regulatory dam. Fish passage to Salmon and Imnaha Rivers requires adequate water quality in China Gardens re-regulatory reservoir. Aeration facilities would be required in the re-regulatory reservoir; but, due to lack of natural turbulence and the large area of lower reservoir, capabilities for aeration at this location would be quite limited and inefficient. Therefore, even if minimum DO levels could be achieved in waters discharged from the re-regulatory dam, the lower reservoir would very likely contain extensive areas of oxygen-deficient waters much of the year. Since the China Gardens damsite is 15.7 miles downstream from the mouth of Salmon River, these DO levels would be deleterious to the Salmon River and Imnaha River anadromous fisheries.

Benefits

This alternative would provide downstream temperature control comparable to that attainable by the Appaloosa development. However, adverse effects created by surges of cold water into the re-regulatory

reservoir, inundation of spawning areas by the re-regulatory reservoir, low dissolved oxygen levels in the re-regulatory reservoir, and physical barriers to Salmon and Imnaha fish runs, would be expected to offset any benefits accruing to project operation for downstream temperature control. A substantial loss in the fishery resource, as compared to "without project" conditions, would occur with development of this alternative.

The Fish and Wildlife Service estimates that this development would destroy the entire anadromous fish run above China Gardens damsite. This loss, compared to "without" project conditions, is estimated to total 48,400 fall chinook, 107,000 spring-summer chinook, 3,500 sockeye salmon and 46,000 steelhead trout annually.

Other water quality effects, with respect to recreational use of the main reservoir and downstream Snake River below the re-regulation reservoir, would compare similarly with those predicted for Appaloosa. Restricted river use within the re-regulatory reservoir with this alternative, however, would extend over about 16 miles; whereas with the Appaloosa re-regulatory reservoir, restricted use would extend over about 5 miles.

High Mountain Sheep Without a Re-regulatory Reservoir

General

Water quality effects similar to those for High Mountain Sheep with China Gardens re-regulatory reservoir would occur except that re-aeration of releases from the high dam will not be feasible without some sort of a re-regulatory facility. Consequently, DO concentrations in downstream impoundments are expected to be below minimum levels specified

in State standards. With operations specifically for power, wide fluctuations in temperature would also result from this alternative. The Fish and Wildlife Service estimates that all anadromous fish using waters upstream from China Gardens would be eliminated; and an additional 3,600 fall chinook annually would be lost due to poor conditions between Asotin and China Gardens sites.

Pleasant Valley, with Re-regulatory Dam at Low Mountain Sheep Site

General

A reservoir at this site would be shallower than Appaloosa or High Mountain Sheep developments, but the impounded waters would be expected to stratify and otherwise exhibit similar water quality characteristics. Temperature stratification and depleted dissolved oxygen concentrations in lower levels could be expected. Algal blooms on reservoir surface waters would occur during periods of stratification.

Temperature

Low level releases from this development would influence downstream water temperatures to about the same extent as the three Hells Canyon dams influence temperatures at present, i.e., the impoundment would lower summer water temperatures slightly and raise temperatures in the fall a corresponding amount. The reservoir storage capacity is too small to provide downstream temperature control through selected depth releases.

Dissolved Oxygen

Aeration facilities would be required in the re-regulatory reservoir. The dissolved oxygen resource of this reach of the river, however, would be generally lower than under "without project" conditions

for extended periods of time. These conditions could interfere with beneficial use of some 21 miles of mainstem Snake River.

Benefits

This alternative would offer no advantages with respect to controls on water quality. The anadromous fish environment would be enhanced only slightly during the summer by the lower temperature releases but the corresponding increases during the fall would be offsetting. Dissolved oxygen depletions created by the project would be more severe than those under "without project" conditions.

Use of the Pleasant Valley Reservoir for resident fishery and recreational purposes would be impaired by heavy algal blooms, as in the case of the other alternatives. Anadromous fish use is expected to remain at the same level as predicted for the "without project" situation. Downstream recreation would be affected very little, if at all, by this alternative.

Without Project

General

Under "without project" conditions, slack water will exist from the mouth of the Snake to the upper end of Asotin Reservoir (river mile 170). Maximum water temperatures throughout most of the lower reach are expected to reach 75 to 76° F in an average year. Under more critical weather conditions, these temperatures, particularly in the lowermost reservoirs, could exceed 80° F. Dissolved oxygen levels are expected to remain near saturation, but will experience wide diurnal fluctuations

due to respiratory and photosynthetic algal activity. Algal blooms are expected to reach nuisance levels in late summer months. Although the chemical and bacteriological quality of water in most reaches of river is expected to remain satisfactory for all uses, high water temperatures and nuisance algal activity may impair the anadromous fishery and recreational use, and the aesthetic attractiveness of the area. Nevertheless, anadromous fish use of Snake River under these conditions is estimated by the U. S. Fish and Wildlife Service to total 66,300 fall chinook, 122,200 spring-summer chinook, 3,500 sockeye, and 113,700 steelhead annually.

In-Line Pump-Back Storage

General

No beneficial effect of pump-back storage on water quality is apparent at this time. Pump-back operations would, in fact, tend to prevent temperature stratification and, thus, eliminate the opportunity to control downstream temperature. No quality benefits would accrue to this type of operation.

Discussion

High dams at either the Appaloosa or High Mountain Sheep site would have potential for downstream temperature enhancement; assuming satisfactory multi-level turbine intake facilities are provided and operated correctly. Pleasant Valley development would have no temperature control capability, but would likely further degrade downstream temperature. Limitations on pump-back operations to the months of January and February would be required to maintain temperature control capabilities of the Appaloosa and High Mountain Sheep alternatives.

Low level releases for temperature control or for other purposes would contain low dissolved oxygen concentrations. Reaeration facilities would be required to replenish the DO of these releases. Reaeration would appear to be best accomplished in a re-regulation reservoir. The feasibility of reaerating peak discharges of 72,000 cfs at Appaloosa Dam, for example, appears questionable. It appears also that DO objectives can be best achieved through a combination of natural and artificial aeration in the re-regulatory reservoir under any alternative condition. It is doubtful, however, that sufficient DO replenishment for fish sur-

vival and passage within the re-regulatory reservoirs below High Mountain Sheep or Pleasant Valley can be achieved. Releases from a High Mountain Sheep development, without re-regulation facilities within which to reaerate or re-regulate temperature releases, would be expected to result in unacceptable DO and temperature conditions downstream.

The Appaloosa development offers considerable opportunity to manage water quality to the greatest benefit of the Salmon and Imnaha River fisheries.

The adverse effects of project-caused DO deficiencies at either High Mountain Sheep alternative would negate the beneficial effects due to temperature enhancement. The Pleasant Valley alternative would degrade both temperature and dissolved oxygen conditions, as compared to the "without project" situation.

Reaeration methods applicable to any alternative require further study with respect to nitrogen entrainment. Reaeration by forcing air into water under pressure (i.e., near the bottom of the afterbay) could cause dissolved nitrogen concentrations to exceed saturation values. If this supersaturated water were released through low level outlets before reaching equilibrium with normal atmospheric saturation, the dissolved nitrogen concentrations downstream would be well above desirable levels. This matter should be investigated thoroughly, through model studies and/or investigation of existing projects, before plans on structures and operating procedures are finalized.

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APPENDIX A

HYDROLOGY

TABLE A-1
PREDICTED INFLOW TO APPALOOSA RESERVOIR
WITH 1985 DEVELOPMENT

YEAR	JULY	AUG	SEPT15	SEPT30	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUNE
1929	9455.	8635.	9550.	11390.	11940.	15467.	14926.	18012.	14639.	22309.	17507.	12833.	10261.	7873.
1930	5566.	8350.	10140.	12120.	12030.	13217.	15286.	19212.	17379.	16292.	11810.	5123.	4440.	5080.
1931	4980.	8693.	11210.	12670.	12160.	12537.	14666.	17042.	14889.	17212.	14360.	9695.	4881.	5269.
1932	7860.	8445.	9350.	10430.	10410.	12360.	11840.	16703.	9930.	20510.	20668.	4980.	11666.	11466.
1933	6200.	8120.	11050.	11830.	12510.	14677.	15226.	16482.	14590.	16883.	7716.	11216.	11426.	17333.
1934	6416.	8495.	10590.	11890.	11860.	14137.	14696.	19582.	15680.	15093.	4710.	6063.	5691.	5540.
1935	5020.	6973.	9835.	10400.	10750.	12487.	14086.	16412.	13970.	14733.	9273.	6020.	5796.	6718.
1936	5386.	8115.	10230.	10850.	11160.	13277.	14096.	17052.	15891.	19537.	11093.	23396.	15963.	12013.
1937	5646.	8845.	11060.	11960.	12590.	14447.	14466.	15902.	16120.	17593.	13500.	15278.	6663.	5360.
1938	5060.	7792.	12829.	12376.	10682.	14057.	17556.	19232.	16230.	23774.	14720.	25234.	25553.	27220.
1939	12190.	8790.	10030.	10810.	13240.	15077.	15956.	17172.	15330.	23070.	22962.	8463.	9336.	6437.
1940	6193.	8840.	11390.	12670.	12730.	13927.	15256.	18202.	19231.	23828.	21345.	14123.	14526.	6444.
1941	6148.	8404.	12260.	13980.	13160.	14997.	16306.	18742.	19270.	21302.	11103.	9191.	10046.	14286.
1942	8276.	11978.	12076.	11407.	9245.	14657.	19046.	19462.	19470.	18730.	11468.	22583.	18526.	19053.
1943	7346.	8690.	11480.	12460.	12830.	15457.	17876.	22158.	30006.	31790.	43623.	69150.	29980.	27860.
1944	17020.	9435.	10610.	11770.	13790.	15327.	16056.	17662.	19381.	19561.	12669.	15688.	6416.	14306.
1945	8423.	10571.	11369.	11874.	11025.	13014.	14768.	17694.	16764.	16883.	12350.	17770.	12380.	18016.
1946	6851.	8879.	10490.	15614.	12980.	13149.	17416.	23883.	24663.	31715.	24030.	43643.	28430.	20593.
1947	6956.	8785.	11670.	12710.	14240.	16127.	19876.	20472.	20960.	24267.	24414.	15383.	17636.	15533.
1948	6351.	8715.	10360.	12880.	12950.	15757.	17386.	20662.	17491.	18893.	11651.	20262.	24146.	27390.
1949	10670.	8720.	10530.	12830.	14580.	15037.	16636.	18152.	21540.	25965.	26551.	26752.	21713.	12343.
1950	6761.	8885.	10660.	12060.	13780.	13607.	15356.	19292.	22240.	24791.	25977.	26469.	20601.	20563.
1951	12401.	10060.	10910.	13050.	15840.	16767.	19666.	21722.	29573.	27870.	25473.	42660.	31570.	22183.
1952	8261.	10260.	10670.	11990.	15610.	15877.	21356.	22612.	25485.	36937.	37673.	79800.	55200.	26080.
1953	13460.	9750.	11870.	12370.	13980.	14547.	16266.	24122.	22120.	23293.	16947.	15793.	17026.	32030.
1954	12490.	9750.	11540.	12440.	14340.	14997.	16816.	19582.	21370.	23302.	18005.	23583.	16286.	16423.
1955	8041.	9370.	10500.	12120.	13940.	14737.	16186.	17952.	16080.	15198.	16735.	14440.	8497.	11713.
1956	7656.	9095.	9130.	11650.	13200.	15097.	23150.	24698.	24531.	31199.	25723.	42910.	35660.	32420.
1957	10990.	10560.	11690.	12850.	15850.	16797.	18486.	18852.	24398.	26255.	26070.	30928.	46050.	31870.
1958	10300.	10360.	11780.	12900.	16190.	15867.	18146.	19842.	25709.	25290.	23568.	40126.	39080.	26020.
AVERAGE:	8,279	9,085	10,895	12,212	12,987	14,580	16,632	19,130	19,564	22,469	18,789	23,326	18,068	16,889

DATA SOURCE: Bonneville Power Administration

02

TABLE A-2
PREDICTED OUTFLOW FROM APPALOOSA RESERVOIR
WITH 1985 DEVELOPMENT
OPERATING WITH 500,000 ACRE FEET OF STORAGE USED FOR DOWNSTREAM TEMPERATURE CONTROL

YEAR	JULY	AUG	SEPT15	SEPT30	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUNE
1929	13110.	13109.	9550.	11390.	11940.	7067.	14926.	19999.	19614.	22309.	17507.	12833.	5000.	6893.
1930	10868.	10869.	10140.	12120.	12030.	5000.	15286.	19999.	19054.	16292.	11810.	5123.	5001.	5000.
1931	11003.	10999.	11210.	12670.	12160.	5000.	14866.	20000.	14889.	17212.	14360.	9895.	5004.	5000.
1932	12218.	12216.	9350.	10430.	10410.	5000.	11840.	20000.	19837.	20510.	20660.	4980.	5001.	5000.
1933	11225.	11225.	11050.	11830.	5000.	5000.	12693.	18469.	19565.	16803.	7495.	5000.	8061.	17333.
1934	11521.	11521.	10590.	11890.	11858.	5737.	14696.	21569.	20655.	15093.	5000.	5000.	5000.	5000.
1935	10042.	10062.	9835.	10400.	5411.	5000.	13202.	18399.	18945.	14733.	8686.	5000.	5000.	5000.
1936	10816.	10816.	10230.	10850.	7935.	5000.	13917.	19008.	20694.	19510.	11149.	10003.	15963.	12013.
1937	11311.	11311.	11060.	11960.	12589.	5128.	14478.	19598.	19412.	18118.	18774.	15344.	5000.	5000.
1938	10658.	10658.	12712.	12466.	7810.	5000.	12395.	21107.	23205.	23774.	14720.	11840.	25553.	27220.
1939	14555.	14555.	10030.	10810.	13239.	6677.	15956.	19159.	20305.	23070.	22962.	5000.	5000.	6338.
1940	11495.	11495.	11390.	12670.	12724.	5561.	15222.	20189.	24034.	23028.	21345.	5000.	12460.	8682.
1941	11226.	11226.	12260.	13980.	13160.	6658.	16275.	20699.	24249.	21247.	11216.	5000.	6158.	18681.
1942	14106.	14106.	12284.	11110	9452.	5000.	15453.	21449.	24445.	18709.	11511.	9190.	18526.	19953.
1943	12084.	12084.	11480.	12460.	12827.	7056.	17876.	24145.	34981.	31790.	43623.	55757.	29580.	27860.
1944	17293.	17293.	10610.	11770.	13768.	6527.	16056.	19649.	24184.	19567.	11020.	13559.	5428.	18366.
1945	13553.	13553.	11385.	11841.	12217.	5229.	14982.	20798.	19861.	20963.	17780.	18969.	5000.	5000.
1946	11931.	11931.	10490.	14914.	16985.	5000.	11526.	25060.	29638.	31715.	24030.	30250.	28430.	20593.
1947	11936.	11936.	11670.	12710.	14238.	7727.	19876.	22409.	25935.	24267.	24414.	5000.	16180.	15533.
1948	11599.	11599.	10360.	12880.	12947.	7357.	17386.	22049.	22294.	18893.	11494.	7046.	24746.	27090.
1949	13760.	13760.	10530.	12830.	14579.	6637.	16636.	20139.	26515.	25965.	26551.	13358.	21713.	12343.
1950	11869.	11869.	10660.	12060.	13777.	5206.	15356.	21279.	27215.	24791.	25977.	13076.	20601.	20563.
1951	15296.	15296.	10910.	13050.	15838.	8367.	19666.	23709.	34548.	27870.	25473.	29267.	31570.	22183.
1952	13326.	13326.	10670.	11590.	15608.	7477.	21356.	24599.	30288.	36937.	37673.	66407.	55200.	26030.
1953	15671.	15671.	11870.	12370.	13978.	6178.	16261.	26083.	27095.	23293.	16947.	5000.	15769.	32030.
1954	15186.	15196.	11540.	12440.	14337.	6597.	16816.	21569.	26345.	23302.	18005.	10190.	16286.	16423.
1955	12771.	12771.	10500.	12120.	13938.	6337.	16186.	19939.	21955.	15119.	15761.	12866.	5000.	9986.
1956	12441.	12441.	9130.	11650.	13198.	6697.	23150.	26685.	29334.	31199.	25723.	29517.	35660.	32420.
1957	14841.	14841.	11690.	12850.	15847.	8397.	18686.	20839.	29373.	26255.	26070.	17935.	46050.	31870.
1958	14396.	14396.	11780.	12900.	16187.	7406.	18146.	21829.	30684.	25290.	23568.	26732.	39080.	26020.
AVERAGE:	12,739	12,739	10,899	12,180	12,533	6,214	16,032	21,347	24,275	22,617	19,044	15,458	17,461	16,352

DATA SOURCE: Bonneville Power Administration

TABLE A-3
PREDICTED OUTFLOW FROM APPALOOSA RESERVOIR
WITH 1985 DEVELOPMENT
OPERATING PRIMARILY FOR POWER PRODUCTION

YEAR	JULY	AUG	SEPT15	SEPT30	OCT	NOV	DEC	JAN	FEB	MAR	APR15	APR30	MAY	JUNE
1929	9455.	8635.	9550.	11390.	11940.	15467.	14926.	19999.	19614.	22309.	17507.	12833.	5000.	6613.
1930	5566.	8350.	10140.	12120.	12030.	13217.	15286.	19999.	19254.	16292.	11810.	5123.	5001.	5000.
1931	5090.	8892.	11210.	12670.	12160.	12737.	14866.	20000.	14089.	17212.	14360.	9895.	5001.	5000.
1932	7860.	8445.	9350.	10430.	10410.	12360.	11840.	20000.	21789.	20510.	20660.	4980.	5001.	5000.
1933	5000.	5000.	11050.	11830.	5552.	14677.	15226.	18469.	19565.	16883.	7718.	5000.	7953.	17333.
1934	6416.	8495.	10590.	11690.	11860.	14137.	14696.	21569.	20655.	15093.	5000.	5000.	5000.	5000.
1935	5000.	5000.	9835.	10400.	7405.	12487.	14086.	18399.	18945.	14733.	9273.	5000.	5000.	5000.
1936	5000.	5000.	10230.	10650.	11153.	13277.	14006.	19039.	20694.	19537.	11693.	10003.	15963.	12013.
1937	5646.	8845.	11060.	11960.	12590.	14447.	14466.	19747.	19626.	18148.	17759.	14869.	5392.	5000.
1938	5000.	6723.	12829.	12376.	9854.	7387.	17556.	21219.	23205.	23774.	14720.	11840.	25553.	27229.
1939	12190.	8790.	10030.	10810.	13240.	15077.	15956.	19159.	20305.	23070.	22962.	5000.	5000.	6353.
1940	6173.	8840.	11390.	12670.	12730.	13927.	15256.	20189.	24034.	23828.	21345.	5000.	12460.	8444.
1941	7063.	9935.	12260.	13980.	10714.	14997.	16306.	20729.	24245.	21302.	11103.	5000.	6300.	18513.
1942	10984.	12631.	12076.	11407.	6624.	8936.	19046.	21449.	24445.	18730.	11468.	9190.	16526.	19353.
1943	7346.	8690.	11480.	12460.	12830.	15457.	17876.	24145.	34981.	31790.	43023.	55757.	33980.	27860.
1944	17020.	9435.	10610.	11770.	13790.	15327.	16056.	19649.	24184.	19561.	12669.	11708.	6227.	17035.
1945	9447.	11157.	11369.	11874.	10545.	12673.	15099.	20762.	20372.	21026.	18039.	18921.	5000.	5000.
1946	7604.	11754.	10490.	15614.	14785.	10303.	14135.	24531.	29638.	31715.	24030.	30250.	26430.	20593.
1947	6556.	8785.	11670.	12710.	14240.	16127.	19876.	22409.	25935.	24267.	24414.	5000.	16980.	15533.
1948	6351.	8715.	10460.	12880.	12950.	15757.	17386.	22049.	22294.	18893.	11651.	6889.	24746.	27000.
1949	10670.	8720.	10530.	12830.	14580.	15037.	16636.	20139.	26515.	25965.	26551.	13358.	21713.	12343.
1950	6761.	8885.	10660.	12060.	13780.	13607.	15356.	21279.	27215.	24791.	25977.	13076.	20601.	20563.
1951	12401.	10060.	10910.	13050.	15840.	16767.	19666.	23709.	34548.	27870.	25473.	29267.	31570.	22183.
1952	8261.	10260.	10670.	11990.	15610.	15877.	21356.	24599.	30288.	36937.	37673.	66407.	55260.	26080.
1953	13460.	9750.	11470.	12370.	13980.	14547.	16266.	26109.	27095.	23291.	16947.	5000.	15768.	32030.
1954	12490.	9750.	11540.	12440.	14340.	14997.	16816.	21569.	26345.	23302.	18005.	10190.	16246.	16423.
1955	8041.	9370.	10560.	12120.	13940.	14737.	16186.	19939.	21055.	15198.	16735.	14440.	5000.	8631.
1956	7656.	9095.	9130.	11650.	13200.	15097.	23150.	26685.	29334.	31199.	25723.	29517.	35660.	32420.
1957	10990.	10560.	11690.	12850.	15850.	16797.	18486.	20839.	29373.	26255.	26070.	17535.	46050.	31870.
1958	10300.	10360.	11780.	12900.	16190.	15807.	18146.	21829.	30684.	25290.	23568.	26732.	39680.	26020.
AVERAGE:	8,404	8,964	10,895	12,212	12,490	14,061	16,534	21,340	24,371	22,626	19,131	15,426	17,501	16,234

DATA SOURCE: Bonneville Power Administration

APPENDIX B

WATER QUALITY

TABLE B-1
WATER QUALITY DATA
SNAKE RIVER NEAR PASCO, WASHINGTON
(River Mile 2.2)

	Discharge cfs	Cations Ca mg/l	Mg mg/l	Na mg/l	K mg/l	Anions Cl mg/l	SO_4 mg/l	F mg/l	HCO_3 mg/l	CO_3 mg/l	Res Filt mg/l	Cond µMho	Total SiO_2 mg/l	Nit. NO_3-N mg/l	Phosphate Ortho mg/l	Total mg/l	Boron B µg/l	Diss. Oxygen mg/l	Coli /100 ml	Temp °C	pH	Color	Hardness Total mg/l	Hardness NC mg/l	Iron Fe µg/l	Turb. JCU
1. Jan-Feb-Mar																										
No. Samples	3	15	15	15	15	15	15	15	15	9	15	15	15	15	13		3	10	10	11	15	15	15	13	10	
Minimum	27,500	17	6	14	2	7	20	0.3	86	0	144	204	2.0	0.3	0.06		.01	11	0	1.9	7.3	5	70	0	70	5
Maximum	37,900	35	16	37	4	18	53	0.6	180	0	284	444	2.6	0.9	0.22		.12	17	930	11	8.1	20	152	8.0	770	80
Average	32,133	26	9	22	3	11	32	0.4	122	0	194	299	2.3	0.6	0.13		.06	14	329	6.1	7.7	10	103	2.5	272	25
2. April-May-June																										
No. Samples	3	16	16	16	16	16	16	16	16	10	16	16	16	16	15		3	11	10	11	16	16	16	16	15	12
Minimum	58,100	7	1	4	1	1	4	0.1	30	0	48	63	0.9	0	0.00		0	9	150	10	7.0	5	21	0	60	5
Maximum	184,900	18	7	14	2	7	19	0.4	85	0	133	199	2.1	0.4	0.15		.06	14	9,300	24	7.8	20	70	1.0	1,100	45
Average	114,000	11	3	8	1	4	11	0.3	54	0	84	123	1.5	0.1	0.07		.02	11	1,737	15	7.4	9	42	0.1	321	17
3. July-Aug-Sept																										
No. Samples	3	17	17	17	17	17	17	17	17	11	17	17	17	17	17		3	13	12	13	17	17	17	17	17	12
Minimum	22,000	12	3	9	1	3	12	0.3	57	0	81	131	1.0	0	0.01		.02	7	0	12	7.2	0	44	0	0	0
Maximum	28,000	31	13	36	4	17	52	0.7	162	1.0	262	419	1.9	0.3	0.17		.08	10	930	27	8.3	10	130	2.0	240	15
Average	25,333	21	7	19	3	9	27	0.4	103	0.1	152	250	1.3	0.1	0.07		.05	9	240	22	7.8	5	83	0.1	118	6
4. Oct-Nov-Dec																										
No. Samples	2	16	16	16	16	16	16	16	16	10	16	16	16	16	15		3	12	13	13	16	16	16	16	15	10
Minimum	28,200	20	7	20	3	10	30	0.3	100	0	161	251	1.2	0.2	0.06		0	10	36	3	7.6	5	80	0	40	0
Maximum	29,200	34	15	39	4	20	56	0.7	177	7.0	284	456	2.6	0.8	0.41		.09	15	2,400	16	8.7	20	148	3.0	250	15
Average	28,700	29	11	29	4	14	42	0.5	143	0.7	223	358	2.0	0.4	0.14		.03	12	548	8	8.0	8	118	0.7	117	4
PERIOD: 7-60/5-66																										
No. Samples	11	64	64	64	64	64	64	64	64	40	64	64	64	64	60		12	46	45	48	64	64	64	64	60	44
Minimum	22,000	7	1	4	1	1	4	0.1	30	0	48	63	0.9	0	0		0	7	0	1.9	7.0	0	21	0	0	0
Maximum	184,900	35	16	39	4	20	56	0.7	180	7.0	284	456	2.6	0.9	0.41		.12	17	9,300	27	8.7	20	152	8.0	1,100	80
Average	51,981	22	8	20	3	10	28	0.4	105	0.2	163	257	1.8	0.3	0.10		.04	11	682	13	7.7	8	86	0.8	202	13

SNAKE RIVER @ INTERSTATE BRIDGE U. S. 410
(River Mile 139.6)

1. Jan-Feb-Mar																										
No. Samples		13	13	13	13	13	13	13	13	7	13	13	13	13	10		1	10	9	10	13	13	13	13	10	10
Minimum		24	7	18	2.5	8	27	0.4	111	0	172	256	2.3	0.3	0.10		0	11	0	2.2	7.4	0	90	0	50	0
Maximum		41	17	41	4.3	20	61	0.8	202	0	310	493	2.8	0.9	0.28		0	21	2,400	12	8.2	15	170	12	1,900	95
Average		33	12	28	3.5	14	42	0.6	155	0	238	375	2.5	0.7	0.17		0	13	413	5.6	7.8	6	132	5	400	19
2. April-May-June																										
No. Samples		10	10	10	10	10	10	10	10	4	10	10	10	10	9		3	5	5	5	10	10	10	10	9	9
Minimum		13	3	8	1.4	3	12	0.2	56	0	88	132	1.1	0.1	0.03		.03	8	91	6.2	7.4	5	45	0	110	10
Maximum		26	10	21	3.1	11	31	0.6	127	0	192	304	2.4	0.4	0.22		.03	10	2,400	20	8.0	15	107	3	1,100	45
Average		18	6	13	2.1	7	19	0.4	85	0	129	199	1.8	0.2	0.10		.03	9	676	13	7.7	9	70	1	513	21
3. July-Aug-Sept																										
No. Samples		10	10	10	10	10	10	10	10	5	10	10	10	10	9			7	7	7	10	10	10	10	8	10
Minimum		16	4	9	1.5	3	14	0.3	71	0	97	153	1.1	0.1	0.03			9	0	17	7.6	5	56	0	0	0
Maximum		32	14	35	4.3	16	49	0.7	162	2.0	251	401	2.4	0.5	0.12			11	430	23	8.4	5	136	3	280	15
Average		25	9	23	2.9	11	33	0.5	122	0.4	180	295	1.7	0.2	0.08			10	143	20	7.9	5	100	1	108	5
4. Oct-Nov-Dec																										
No. Samples		12	12	12	12	12	12	12	12	6	12	12	12	12	10		2	8	9	9	12	12	12	12	9	9
Minimum		29	12	29	3.3	12	42	0.5	144	0	227	367	1.5	0.2	0.07		.03	8	0	4	7.7	0	121	0	30	0
Maximum		42	16	38	4.3	18	58	0.7	198	0	288	472	2.6	0.7	0.22		.04	14	4,600	13	8.4	5	167	4	170	5
Average		35	14	35	3.8	16	51	0.6	171	0	264	425	2.3	0.5	0.15		.03	11	598	8	7.9	3	143	1	79	2
PERIOD: 10-61/4-66																										
No. Samples		45	45	45	45	45	45	45	45	22	45	45	45	45	38		6	30	30	31	45	45	45	45	36	38
Minimum		13	3	8	1.4	3	12	0.2	56	0	88	132	1.1	0.1	0.03		0	8	0	2.2	7.4	0	45	0	0	0
Maximum		42	17	41	4.3	20	61	0.8	202	2.0	310	493	2.8	0.9	0.28		.04	21	4,600	23	8.4	15	170	12	1,900	95
Average		28	11	25	3.2	12	37	0.5	137	0.1	208	332	2.1	0.4	0.13		.03	11	449	11	7.9	6	114	2	283	12

DATA SOURCE: Geological Survey, in cooperation with Washington State Pollution Control Commission.

TABLE B-2
WATER QUALITY DATA
SNAKE RIVER @ WPSS ICE HARBOR DAM
(River Mile 9.7)

	Discharge cfs	Dissolved Oxygen mg/l	BOD 5-day mg/l	COD mg/l	Chloride Cl mg/l	Total Alkalinity mg/l	Total Hardness mg/l	Sulfate SO_4 mg/l	Residue Non-filt. mg/l	Residue Filt. mg/l	Ortho PO_4 mg/l	Nitrate NO_3-N mg/l	Color	Turbidity JCU	pH	Temp. °C.
1. January																
No. Samples	8	4	4	3	13	13	13	14	4	10		4	10	13	7	1
Minimum	22,200	12	0.9	0.9	8	74	80	25	38	200		.68	0	25	7.3	2.8
Maximum	53,700	13	1.8	2.8	19	156	157	55	42	306		.70	15	90	8.1	4.9
Average	31,888	12	1.4	1.6	14	123	121	42	40	256		.70	7	31	7.8	4.0
2. February																
No. Samples	7	3	3	3	11	11	11	11	3	9		2	11	11	5	4
Minimum	22,200	12	0.8	1.0	3	41	38	14	36	160		.68	5	25	7.8	4.2
Maximum	130,000	12	1.0	1.4	18	148	174	47	63	280		1.0	25	600	8.1	10
Average	46,857	12	0.9	1.2	12	106	112	35	47	239		.84	9	82	7.9	6.0
3. March																
No. Samples	10	3	2	3	14	14	12	14	5	11		2	14	13	4	3
Minimum	24,400	11	0.7	0.3	5	73	80	10	22	138		.62	0	25	6.9	5
Maximum	89,200	13	1.3	2.6	17	134	140	120	47	270		.80	17	76	7.9	7
Average	37,220	12	1.0	1.4	11	97	99	36	38	192		.71	10	29	7.3	6.5
4. April																
No. Samples	11				11	11	11	11	3	9		3	11	11	4	1
Minimum	44,000				4	54	44	15	38	93		.40	5	25	7.2	8.5
Maximum	67,600				11	88	91	31	50	142		.60	20	25	7.7	8.5
Average	54,490				7	66	63	20	42	113		.47	10	25	7.4	8.5
5. May																
No. Samples	11				9	9	9	10	3	7		2	10	9		2
Minimum	63,100				3	32	38	8	41	62		.10	0	25		10
Maximum	184,000				11	68	62	20	43	126		.10	15	25		10
Average	107,218				6	53	51	13	42	98		.10	8	25		10
6. June																
No. Samples	10				10	10	10	10	6	9		2	9	9		6
Minimum	102,000				2	28	26	5	30	52		.10	0	25		11
Maximum	225,890				11	50	52	17	61	110		.10	10	25		16
Average	150,520				6	41	41	11	39	81		.10	5	25		13
7. July																
No. Samples	8			1	10	10	10	10	4	8	1	2	8	8		2
Minimum	24,800			13	3	44	42	13	3	82	.01	.10	5	25		17
Maximum	81,600			13	9	64	72	18	39	127	.01	.10	15	25		22
Average	41,722			13	6	55	59	16	22	101	.01	.10	7	25		19
8. August																
No. Samples	14			1	18	18	18	18	9	17	4	1	18	13		8
Minimum	17,800			22	4	64	24	15	1	117	.01	.10	0	0		20
Maximum	31,300			22	13	90	101	32	41	159	.03	.10	20	25		24
Average	22,850			22	8	77	76	23	19	138	.02	.10	8	19		23
9. September																
No. Samples	11				15	15	14	15	9	15	4		15	15		4
Minimum	17,600				9	84	82	20	1	159	.01		0	1		18
Maximum	29,600				20	116	204	165	40	425	.02		10	25		23
Average	21,936				13	99	105	42	17	204	.02		7	19		21
10. October																
No. Samples	12				15	15	15	15	5	12		2	13	14	4	3
Minimum	17,900				9	88	80	30	17	160		.10	0	1	7.3	14
Maximum	56,100				18	131	122	50	37	248		.40	20	25	8.0	16
Average	26,633				15	114	111	41	27	217		.25	8	23	7.8	15
11. November																
No. Samples	10				10	10	10	10	5	9		1	7	10	4	2
Minimum	22,700				6	62	84	19	13	150		.20	0	25	7.7	11
Maximum	36,500				50	168	256	215	34	535		.20	15	25	8.1	11
Average	27,470				19	115	131	58	26	255		.20	7	25	8.0	11
12. December																
No. Samples	12	1	1	1	13	14	14	14	6	12		3	11	13	6	1
Minimum	21,500	12	0.7	8	7	82	46	25	24	150		.20	0	25	7.5	5.6
Maximum	41,100	12	0.7	8	18	138	164	50	38	280		.39	15	25	8.1	5.6
Average	30,767	12	0.7	8	13	113	113	39	33	223		.30	6	25	7.8	5.6
PERIOD: (1957) 1962-1967																
NO. SAMPLES	126	11	10	12	149	150	147	152	62	128	9	24	137	139	34	41
MINIMUM	17,600	11	0.7	0.3	2	28	24	5	1	52	.01	.10	0	0	6.9	2.8
MAXIMUM	225,890	13	1.8	22	50	168	256	215	63	535	.03	.80	25	600	8.1	24
AVERAGE	48,971	12	1.1	4.6	21	90	91	32	30	180	.015	.40	7	29	7.7	13.3

DATA SOURCE: Federal Water Pollution Control Administration (Water Pollution Surveillance System)

TABLE B-3
WATER QUALITY DATA
SNAKE RIVER AT WAWAWAI, WASHINGTON
(River Mile 110.8)

	Discharge cfs	Chloride Cl mg/l	Sulfate SO_4 mg/l	Residue Non-filt. mg/l	Residue Filt. mg/l	Nitrate NO_3-N mg/l	Ortho Phosphate PO_4 mg/l	Dissolved Oxygen mg/l	BOD 5-day mg/l	COD mg/l	Temp. °C	pH	Color	Turbidity JCU	Total Alkalinity $CaCO_3$	T. Hardness $CaCO_3$
1. January																
No. Samples	39	34	34	16	34	2		34	29	33	34	33	31	33	34	34
Minimum	22,200	5.0	16	9	116	.36		12	6	.9	0	7.5	3	0	57	60
Maximum	63,000	19	55	180	282	.70		16	5.4	35	8.0	8.5	65	250	164	156
Average	32,805	14	42	51	225	.62		13	2.1	10	3.5	8.0	16	25	117	120
2. February																
No. Samples	35	34	33	14	34	3		34	30	33	34	34	32	32	34	34
Minimum	24,300	5.0	21	6	135	.60		10	.6	1.3	1.0	6.7	4	3	54	53
Maximum	100,000	18	52	119	274	.90		13	4.0	63	8.3	8.6	40	400	144	153
Average	40,922	12	34	38	202	.73		12	1.8	12	4.0	8.0	19	46	103	104
3. March																
No. Samples	40	37	35	15	35	2		37	33	34	35	37	31	34	37	37
Minimum	23,600	0	12	20	87	.42		10	0	1.1	3.0	6.6	3	5	14	6
Maximum	89,500	18	43	229	243	.70		13	3.3	104	9.0	8.4	65	370	135	132
Average	42,362	9.9	30	56	172	.56		12	1.7	14	5.8	7.9	20	42	88	89
4. April																
No. Samples	37	32	30	15	29	1		31	30	31	32	32	31	32	32	32
Minimum	44,000	2.0	8	20	67	.25		10	0	3.6	7.0	7.0	9.	1	28	28
Maximum	183,000	15	32	212	151	.25		14	3.6	35	10	8.3	47	305	77	65
Average	70,310	5.5	16	53	104	.25		11	1.7	12	8.9	7.7	21	31	52	50
5. May																
No. Samples	40	35	32	14	34	3		35	32	34	33	35	33	34	35	35
Minimum	49,200	1.0	4	24	46	.10		9	.3	7.0	8.2	7.1	6	2	14	15
Maximum	167,000	10	19	76	161	.20		12	3.0	24	13	8.2	31	200	63	58
Average	102,555	3.5	11	43	76	.13		10	1.5	12	11	7.7	17	24	36	36
6. June																
No. Samples	40	33	29	14	35	2		34	33	34	35	35	33	35	35	35
Minimum	38,100	1.0	5	11	44	.10		8	.4	4.0	9.2	7.0	6	0	20	18
Maximum	240,000	5.0	22	92	106	.10		11	2.9	27	21	8.9	48	290	52	54
Average	123,995	2.8	10	38	70	.10		10	1.1	11	14	7.7	16	28	36	34
7. July																
No. Samples	39	36	35	16	37	2	1	35	32	34	33	35	35	35	37	37
Minimum	17,300	3.0	10	5	0	.10	.01	7	.3	4.0	17	7.4	9	0	41	36
Maximum	86,200	11	28	65	174	.10	.01	12	3.0	17	24	9.2	23	175	88	92
Average	37,733	5.8	16	32	105	.10	.01	8	1.2	9.1	21	8.1	15	15	58	56
8. August																
No. Samples	42	45	41	18	44	1	3	41	37	40	43	40	42	43	45	45
Minimum	14,100	1.0	15	3	106	.10	.01	7	.4	1.0	18	7.3	5	1	60	61
Maximum	31,300	16	42	59	226	.10	.03	10	3.8	24	27	9.1	39	115	117	113
Average	21,371	10	29	26	169	.10	.02	8	1.4	11	22	8.2	15	15	89	90
9. September																
No. Samples	39	42	41	21	40	2	4	38	35	36	40	37	40	42	42	42
Minimum	10,900	5.0	11	2	142	.10	.04	7	.5	6.0	15	7.6	5	0	85	78
Maximum	49,000	48	465	66	479	1.8	.07	11	2.6	19	23	9.0	24	40	135	136
Average	23,110	13	56	25	216	.95	.06	9	1.4	10	19	8.3	14	12	108	110
10. October																
No. Samples	35	39	39	17	37	1		34	34	35	39	38	38	40	38	38
Minimum	17,600	5	21	27	129	.60		7	.3	5.0	10	7.6	5	0	58	61
Maximum	59,900	75	56	76	268	.60		17	4.6	17	18	8.6	26	39	127	142
Average	28,740	17	43	38	222	.60		10	1.6	11	14	8.1	16	15	113	113
11. November																
No. Samples	34	39	38	13	38	1		36	37	35	39	39	39	39	39	39
Minimum	18,800	6	26	14	122	.10		9	.6	4.0	0.5	7.3	3	2	66	62
Maximum	46,800	18	59	53	274	.10		12	6.0	25	13	8.5	30	245	150	154
Average	30,564	13	40	31	211	.10		11	2.1	10	8.5	8.0	15	22	110	111
12. December																
No. Samples	34	37	36	11	36	3		37	32	36	37	36	37	37	37	37
Minimum	21,000	6	20	2	124	.20		10	.4	5.8	2.0	7.2	4	0	60	52
Maximum	97,500	19	56	42	297	.40		13	5.6	30	10	8.4	33	87	134	160
Average	33,900	13	40	22	212	.33		12	2.1	11	5.1	7.9	14	17	108	110
PERIOD: 1957-1967																
NO. SAMPLES	434	443	423	184	433	23	8	426	394	415	434	431	426	436	445	445
MINIMUM	10,900	0	4	2	0	.10	.01	7	0	.9	0	6.6	3	0	14	6
MAXIMUM	240,300	75	465	229	479	1.8	.07	16	6.0	104	27	9.2	65	400	154	160
AVERAGE	49,643	10	31	37	167	0.40	.036	10	1.9	11	11.6	8.0	16	23	85	86

DATA SOURCE: Federal Water Pollution Control Administration
(Water Pollution Surveillance System)

TABLE B-4
WATER QUALITY DATA
SNAKE AND CLEARWATER RIVERS
JULY-AUGUST 1963

RIVER MILE STATION NUMBER	CLW-2.6 13	CLW-0.8 12	S-141.1 1	S-139.8 2	S-139.0 3	S-136.9 4	S-135.0 5	S-132.3 6	S-128.0 7	S-123.2 8	S-119.2 9	S-115.0 10	S-110.5 11
mg/l Diss. Oxygen													
No. Samples	17	54	60	60	150	120	116	116	48	48	48	48	48
Minimum	6.7	8.0	5.0	8.4	7.9	8.1	8.0	8.0	7.8	7.8	7.9	8.0	8.0
Maximum	8.6	9.4	10.4	10.3	10.0	10.0	9.9	9.9	9.8	9.6	9.5	9.5	9.4
Average	7.2	8.5	9.3	9.4	9.0	9.1	9.1	9.0	8.7	8.7	8.6	8.7	8.7
Percent Saturation													
Average	81	94	102	104	101	101	101	101	98	97	97	97	97
mg/l BOD 5-day													
No. Samples	18	18	19	20	29	30	29	27	12	12	12	12	12
Minimum	0.80	0.40	1.83	0.91	1.08	1.48	1.50	1.40	3.40	2.60	2.40	2.10	2.18
Maximum	2.69	3.37	4.70	3.68	3.44	3.30	3.06	3.30	8.90	6.40	5.60	5.50	4.30
Average	1.37	1.34	2.96	2.21	2.00	2.12	2.36	2.13	5.67	3.88	3.48	3.46	3.12
mg/l COD													
No. Samples	13	12	15	15	25	24	23	23	12	12	12	12	12
Minimum	2.4	0.8	2.4	3.5	5.9	4.5	3.4	4.1	13.0	8.0	7.2	6.7	6.7
Maximum	6.9	9.7	14.3	12.5	15.0	12.1	11.8	10.5	21.9	21.8	15.4	17.2	14.4
Average	4.9	6.7	10.6	8.2	9.7	9.5	9.4	9.2	15.5	13.3	11.5	11.3	11.0
pH													
No. Samples	18	18	19	20	30	30	29	29	11	11	11	11	11
Average	7.50	7.84	8.60	8.67	8.47	8.51	8.54	8.48	8.27	8.38	8.41	8.35	8.44
°C Temp													
No. Samples	17	18	20	20	30	30	29	29	12	12	12	12	12
Maximum	25.4	23.0	22.5	22.0	23.5	22.5	22.5	22.5	24.0	23.5	23.5	23.5	23.5
Average	22.0	20.9	20.7	20.6	21.1	21.0	21.0	21.0	21.5	21.5	21.5	21.5	22.0
mg/l T. Alkalinity													
No. Samples	14	14	16	16	15	15	15	15					
Average	24.0	19.2	85.2	85.0	62.3	72.0	72.5	70.9					
mg/l T. Hardness													
No. Samples	14	14	16	16	15	15	15	15					
Average	19.2	15.4	87.4	87.5	62.2	74.6	73.6	72.4					
mg/l Sulfates													
No. Samples	13	13	15	15	24	14	14	14	10			10	
Average	2.6	1.1	19.3	18.1	13.5	14.7	14.8	14.7	18.6			18.9	
mg/l Nitrates-N													
No. Samples	14	13	15	15	14	14	14	14	1			1	
Average	.20	.03	.04	.04	.04	.04	.04	.04	0			0	
mg/l Ortho PO_4													
No. Samples	13	13	15	15	14	14	14	14	12			12	
Average	.04	.02	.04	.04	.05	.04	.05	.05	.06			.06	
mg/l T. Solids													
No. Samples	14	13	15	15	22	22	20	20	7	7	7	7	7
Average	47	16	140	132	101	124	118	108	120	118	114	120	114
mg/l Sett. Solids													
No. Samples	4	5	4	2	24	24	5	5					
Average	.06	.03	.07	.07	.12	.14	.11	.12					

DATA SOURCE: Water Quality Effects of Lower Granite Dam, Snake River
--Public Health Service, November 1964

TABLE B-5
COMPARISON OF WATER QUALITY ABOVE AND BELOW
THE BROWNLEE-OXBOW RESERVOIRS

Location	Date	Time	Temp °F	pH	DO	N(mg/l)		PO_4(mg/l)			Solids(mg/l)		
					mg/l	NH_3	NO_3	Ortho	Solub	Tot.	Tot.	Diss.	Susp.
Weiser	10/7/65	1450	62.6	8.0	10.9	--	0.46	0.12	--	0.23	358	320	38
Oxbow Dam		1740	--	-	--	--	0.51	0.18	--	0.19	322	299	23
Weiser	7/6/66	1130	72.3	8.5	--	0.13	0.02	0.11	0.12	0.38			
Oxbow Dam		1515	62	8.4	--	--	0.18	0.08	0.08	0.13			
Weiser	7/21/66		70	8.4	9.0	0.07	0.02	0.09	0.11	0.34	508		14
Oxbow Dam			66	8.4	6.0	0.37	0.12	0.06	0.05	0.13	276		3
Weiser	8/3/66		81	8.4	12.4	0.06	0.03	0.09	0.10	0.41	386		78
Oxbow Dam			71	8.2	6.0	<0.05	0.06	0.05	0.05	0.14	271		26
Weiser	8/19/66		76	8.4	12.7	0.09	0.14	0.03	0.07	0.26	387		68
Oxbow Dam			73	8.4	6.5	0.13	0.09	<0.01	0.06	0.18	286		20
Weiser	9/1/66		68	8.4	11.5	0.07	0.16	0.07	--	0.28	392		50
Oxbow Dam			71	8.2	5.9	0.12	0.09	0.09	--	0.12	277		--
Weiser	10/7/66	1640	--	8.4	16.3	<0.05	0.37	0.10	--	0.21			
Oxbow Dam		1400	--	7.3	5.4	0.25	0.19	0.18	--	0.14			
Weiser	11/3/66	1110	50.7	8.2	11.0	<0.05	0.49	0.05	--	0.12			
Oxbow Dam		1440	58.0	7.8	6.5	0.21	0.35	0.16	--	0.27			

DATA SOURCE: FWPCA Snake River - Boise River Surveys

TABLE B-6
REPORTED DISCHARGES AND WATER TEMPERATURES
OF THE LOWER SNAKE RIVER

Date	Weiser (R.M. 351.3)		Brownlee Dam (R.M. 285.0)		Above Clearwater (R.M. 139.6)	Ice Harbor Dam (R.M. 9.7)		Clearwater at Spalding (R.M. S139.3-C11.6)		Salmon at White Bird (R.M. S188.2-S53.7)	
	°F	cfs	°F	cfs	°F	°F	cfs	°F	cfs	°F	cfs
1967											
8/15-8/21	76	10,700	68	9,100	74.5	75	18,000	69	2,800	70.5	5,000
8/9-8/15	-	10,700	-	10,000	72.5	74	20,000	68	3,450	69.5	5,800
7/25-7/31	76	10,200	70.5	9,800	72	72.5	25,500	-	3,250	69	8,700
7/18-7/24	75	10,000	65	10,000	70	71.5	32,000	67	7,200	-	12,000
7/12-7/18	75	10,900	65.5	11,000	69	69	42,000	-	11,200	-	15,900
7/5-7/11	74	13,200	66	13,200	65.5	66.5	63,700	61.5	16,100	-	25,300
6/28-7/4	71	18,000	64	17,200	62.5	61.5	93,000	-	25,400	57.5	39,700
6/21-6/28	68	21,900	64	19,700	59	58	148,000	52.5	43,500	53.5	59,200
6/7-6/13	62.5**	22,800	59	10,500	54	55	151,000	48.5	62,000	51	58,800
5/31-6/6	59.5	20,500	57	9,300	53.5	53	140,000	47.5	59,600	49	54,500
5/24-5/30	61	20,950	58.5	9,400	54	54	174,000	47	75,000	47	63,800
5/17-5/23	58.5	18,200	55.5	10,900	54	53.5	140,000	48	66,000	53	42,800
1966											
11/23-11/29	53.5	12,700	49.5	12,700	48	46.5	24,400	39.5	4,370	43.5	4,260
11/16-11/22	54.5	13,000	51.5	13,800	50	48.5	27,600	40	6,950	41	4,250
11/9-11/15	52.5	13,200	52.5	11,200	50	51.5	22,400	40	4,580	-	4,090
11/2-11/8	54.5	13,000	53.5	13,100	54	53.5	21,600	-	3,240	44.5	3,940
10/19-10/25	54	14,400	58.5	14,000	57	57	22,000	44.5	3,660	44	3,840
10/12-10/18	55.5	15,000	61.5	14,100	60	62	20,800	47.5	2,670	50	3,610
10/5-10/11	60.5	13,900	64	14,000	63.5	65	20,900	53	2,760	53.5	3,540
9/21-9/27	62.5	12,700	66	12,100	68	68	18,600	66	2,220	61.5	3,600
9/14-9/20	62	12,800	66.5	13,100	68	68	19,000	64.5	2,820	61	3,400
9/7-9/13	65	11,800	68	11,900	71	68.5	17,900	68	2,220	67	3,000
8/31-9/6	63.5	11,700	67	12,900	69	70.5	19,000	65	2,850	65.5	2,680
8/24-8/30	65	10,800	66	11,400	70	72	16,600	70.5	2,990	68.5	3,000
8/17-8/23	64	10,000	66	8,900	70	73.5	15,400	69.5	2,240	69	3,080
8/10-8/16	65	9,900	-	10,000	71	74.5	17,000	70.5	2,510	70	3,450
8/3-8/9	67.5	10,050	68.5	10,400	72	74	17,400	73.5	2,960	72	3,720
7/27-8/2	67	9,600	67	9,300	70.5	73.5	19,200	72.5	3,620	68	4,100
7/20-7/26	67.5	9,200	67	9,880	70.5	72.5	20,600	71.5	4,600	66.5	4,800

* Near Clarkston, Washington, R.M. 134.

** All temperatures below @ King Hill, Idaho, R.M. 545.6.

DATA SOURCE: U. S. Geological Survey

APPENDIX C

Economic Base Study and Forecast
Lower Snake River Basin

Present Economy

The demand for water for all uses, and the amount and character of wastes expected to be discharged to these waters, are determined largely by the activities associated with a region's economic base. The purpose of this section is to present the economic and demographic data for use in projecting future uses and wastes to be expected in lower Snake River surface waters.

The basin economy is dominated by agriculture and the processing of forest products. As shown in Table C-1, 30 percent of the 1960 labor force was employed in these two categories. The 1960 population (155,000) is concentrated where these forestry and agricultural activities are dominant. Service areas supporting these activities have developed at Lewiston (33,700 population in 1960, including Clarkston and the immediate area), and in the Pullman-Moscow area (25,000 population in 1960). Two major schools--Washington State University in Pullman and the University of Idaho in Moscow--are responsible for much of this growth in the latter area. Population of the Lower Snake Basin in 1960 is shown in Table 3.

The pulp mill at Lewiston owned by Potlatch Forest, Inc., which is capable of producing 750 tons of kraft pulp, 600 tons of paperboard, and 50 tons of tissue per day, is the largest industrial installation in the basin. Other waste producing industries include a food processing plant at Lewiston and two meat packing firms in Clarkston.

During the 1950 to 1960 period, agricultural employment (see Table C-1) declined 26 percent, and employment in manufacturing (dominated by the forest products industry), services, and governmental activities increased over 16 percent. As suggested by the shift in employment from agriculture to manufacturing and services, rural population declined during the decade,

TABLE C-1
Lower Snake River Basin Employment by Industry

Industry	1960 Total	% of Total	% Increase since 1950
Agriculture	9,900	18.0	-26.3
Mining	240	0.4	-52.8
Construction	2,960	5.4	-12.9
Manufacturing	9,070	16.5	24.6
Forest products	(6,780)	(12.3)	17.6
Other durables	(410)	(0.8)	79.0
Food & kindred	(1,010)	(1.8)	45.1
Chemical and allied	(90)	(0.2)	225.0
Other nondurables	(770)	(1.4)	34.1
Transportation & warehousing	2,110	3.9	-11.3
Communications & utilities	940	1.7	- 7.0
Wholesale trade	1,480	2.7	24.1
Retail Trade	8,600	15.6	12.3
Finance and service	11,000	20.0	20.6
Education and Government	8,720	15.8	20.6
Total	55,020	100.0	

and a corresponding increase in population occurred in urban areas. Total basin population increased a modest 0.5 percent annually during the 10-year period.

Economic and Population Projections

Future economic conditions were projected by extending recent production growth trends, assuming that the rate of output increase will eventually equal the rate of national population increases which is considered to be the limiting factor for markets. In cases where output's growth rate has outstripped that of population, it was assumed the rate of increase would diminish in normal regression fashion to meet population growth trends. These projected production trends were further modified by limiting projected growth where it appeared resource capabilities were being fully utilized, and by increasing growth rates where significant resources were being underutilized.

Based on employment projections developed using the procedures described, future populations in the basin were estimated as shown in Table 3. Recent trends in employment and population distributions are expected to continue in the future, as rural populations decline and urban areas grow at the combined rates of over-all population growth, plus rate of decline in rural areas.

By 2020, two-thirds of the lower basin's populations are expected to be concentrated in the Lewiston and Pullman-Moscow service areas, reflecting the trends toward industrialization and increased service requirements in urban areas.

TABLE C-2
POPULATION PROJECTIONS FOR LOWER SNAKE RIVER BASIN
(1000 persons)

	1960	1980	2000	2020
Lewiston-Clarkston service area	33.7	55.2	90.4	148.0
Pullman-Moscow service area	25.0	38.4	58.2	86.4
LaGrande service area	10.2	13.4	17.6	23.2
Communities over 250 Population	38.9	47.6	58.4	61.8
Rural	47.4	39.6	33.7	29.3
Total Basin	155.2	194.2	258.3	348.7

APPENDIX D

Present and Projected Waste Sources

Municipal, Industrial and Agricultural Pollution

Municipal and Industrial

Waste loadings to lower Snake surface waters from municipal and industrial sources, in 1965 and projected to 2020 with interim points at 1980 and 2000, are tabulated in Table D-1, D-2, D-3, D-4, and D-5. Future loadings are based on industrial and population projections shown in Appendix C. These loadings come from population and industrial centers in the LaGrande, Lewiston-Clarkston, and Pullman-Moscow service areas. Table D-1 summarizes the loadings by service areas for 1965, 1980, 2000, and 2020. Both the Grande Ronde River, which receives wastes from the LaGrande area, and the Palouse River, which receives Pullman area wastes, are fast flowing streams having high reaeration capabilities. Although local problems could occur because of these loads (the South Fork Palouse is polluted at present by Moscow-Pullman wastes which receive secondary treatment) these problems do not extend to the mainstem Snake and are not expected to do so in the future. The wastes from the Lewiston area discharge into the mainstem Snake, however, and downstream water quality is directly related to the amount and character of these wastes.

The Potlatch Forest, Inc. pulp and paper mill at Lewiston is the largest single water user and waste producer in the basin. In 1965, the untreated wastes from this mill, estimated at 432,000 population equivalents (PE), were almost three times as large as all other wastes produced in the three service areas. Mill officials recently announced plans to construct treatment facilities capable to removing 95 percent of the settleable suspended solids carried in the waste waters. Construction of

TABLE D-1
LOWER SNAKE RIVER BASIN
PEAK WASTE LOADINGS, 1000 PE

	1965		1980	2000	2020
	Raw	Discharged	Raw	Raw	Raw
Lewiston-Clarkston service area	45.1	29.3	69.0	113.0	185.0
Municipal	45.1	29.3	69.0	113.0	185.0
Industrial	488.8	488.3	374.6	722.6	1065.1
Total M&I	533.9	517.6	443.6	835.6	1250.1
Pullman-Moscow service area					
Municipal	36.6	5.5	48.0	72.8	108.0
Industrial	--	--	3.5	4.9	6.4
Total M&I	36.6	5.5	51.5	77.7	114.4
LaGrande service area					
Municipal	13.6	2.1	16.8	22.0	29.0
Industrial	--	--	98.0	163.1	271.6
Total M&I	13.6	2.1	114.8	185.1	300.6

the treatment facilities, consisting of clarifier and filtration units, is to begin immediately and will require more than a year to complete. This plant should do much to solve nuisance conditions in the Snake River below Lewiston.

Other waste sources in the Lewiston area include the cities of Lewiston, Clarkston, and Asotin, two meat packing plants, and two food processing plants. In 1965, raw waste production in the Lewiston area, including the Potlatch Forests mill, was estimated to total 540,000 PE.

TABLE D-2
LOWER SNAKE RIVER BASIN
RAW WASTE LOADS
1965

SERVICE AREA	CATEGORY	MONTH (1000 PEs) J	F	M	A	M	J	J	A	S	O	N	D
LEWISTON	Municipal	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45.1	45
	Industrial												
	Potato Processing	47.5	47.5	45.0	45.0	37.5	0	0	15.0	45.0	50.0	50.0	50
	Meat Products	5.0	4.0	4.5	4.8	4.8	4.8	4.8	4.8	5.3	5.3	4.8	5
	Milk Products	1.6	1.5	1.7	1.8	2.0	2.0	1.9	1.8	1.6	1.5	1.4	1
	Canning and Freezing	0	0	0	0	0	28.8	37.0	28.8	0	0	0	0
	Pulp and Paper	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.
	TOTAL M & I	531.2	530.1	528.3	528.7	521.4	512.7	520.8	527.5	529.0	533.9	533.3	533.
PULLMAN	Municipal	36.6	36.6	36.6	36.6	36.6	19.1	19.1	19.1	36.6	36.6	36.6	36.
	Industrial												
	Meat Products												
	Milk Products												
	TOTAL M & I	36.6	36.6	36.6	36.6	36.6	19.1	19.1	19.1	36.6	36.6	36.6	36.
LA GRANDE	Municipal	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.
	Industrial												
	Milk Products												
	Canning and Freezing												
	TOTAL M & I	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.6	13.

TAB D-3
LOWER SNAKE RIVER BASIN
DISCHARGE WASTE LOADS
1965

SERVICE AREA	CATEGORY	MONTH (1000 PEs) J	F	M	A	M	J	J	A	S	O	N	D
LEWISTON	Municipal	29.3	29.3	9.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.
	Industrial												
	Potato Processing	47.5	47.5	45.0	45.0	37.5	0	0	15.0	45.0	50.0	50.0	50.
	Meat Products	5.0	3.8	4.5	4.8	4.8	4.8	4.8	4.8	5.3	5.3	4.8	5.
	Milk Products	1.0	1.0	1.1	1.2	1.3	1.3	1.2	1.2	1.0	1.0	0.9	1.
	Canning and Freezing	0	0	0	0	0	18.7	24.1	18.7	0	0	0	0
	Pulp and Paper	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.0	432.
	TOTAL M & I	514.8	513.6	511.9	512.3	504.9	486.1	491.4	501.0	512.6	517.6	517.0	517.
PULLMAN	Municipal	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.
	Industrial												
	Meat Products	0	0	0	0	0	0	0	0	0	0	0	0
	Milk Products	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL M & I	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.
LA GRANDE	Municipal	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.
	Industrial												
	Milk Products	0	0	0	0	0	0	0	0	0	0	0	0
	Canning and Freezing	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL M & I	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.

TABLE D-4
LOWER SNAKE RIVER BASIN
PROJECTED RAW WASTE LOADS
1980

SERVICE AREA	CATEGORY	MONTH (1000 PEs) J	F	M	A	M	J	J	A	S	O	N	D
LEWISTON	Municipal	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.0	69.
	Industrial												
	Potato Processing	42.9	42.9	40.5	40.5	33.9	0	0	13.5	40.5	45.0	45.0	45.
	Meat Products	3.9	3.1	3.5	3.7	3.7	3.7	3.7	3.7	4.1	4.1	3.7	4.
	Milk Products	1.6	1.5	1.7	1.8	2.0	2.0	1.9	1.8	1.6	1.5	1.4	1.
	Canning and Freezing	0	0	0	0	0	108.0	140.4	108.0	0	0	0	0
	Pulp and Paper	324.0	324.0	324.0	324.0	324.0	324.0	324.0	324.0	324.0	324.0	324.0	324.
	TOTAL M & I	441.4	440.5	438.7	439.0	432.6	506.7	539.0	520.0	439.2	443.6	443.1	443.
PULLMAN	Municipal	48.0	48.0	48.0	48.0	48.0	26.8	26.8	26.8	48.0	48.0	48.0	48.
	Industrial												
	Meat Products	1.6	1.2	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.5	1.
	Milk Products	1.6	1.5	1.7	1.8	2.0	2.0	1.9	1.8	1.6	1.5	1.4	1.
	TOTAL M & I	51.2	50.7	51.1	51.3	51.5	30.3	30.2	30.1	51.2	51.1	50.9	51.
LA GRANDE	Municipal	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.8	16.
	Industrial												
	Milk Products	0.6	0.6	0.7	0.7	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.
	Canning and Freezing	0	0	0	10.8	10.8	75.6	97.2	75.6	0	0	0	0
	TOTAL M & I	17.4	17.4	17.5	28.3	28.4	93.2	114.8	93.1	17.4	17.4	17.4	17.

TABLE D-5
LOWER SNAKE RIVER BASIN
PROJECTED RAW WASTE LOADS
2000

SERVICE AREA	CATEGORY	MONTH (1000 PEs) J	F	M	A	M	J	J	A	S	O	N	D
LEWISTON	Municipal	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.0	113.
	Industrial												
	Potato Processing	57.0	57.0	54.0	54.0	45.0	0	0	18.0	54.0	60.0	60.0	60.
	Meat Products	5.5	4.4	5.0	5.3	5.3	5.3	5.3	5.3	5.8	5.8	5.3	5.
	Milk Products	2.2	2.1	2.4	2.5	2.8	2.8	2.7	2.5	2.2	2.1	2.0	2.
	Canning and Freezing	0	0	0	0	0	183.6	237.6	183.6	0	0	0	0
	Pulp and Paper	477.0	477.0	477.0	477.0	477.0	477.0	477.0	477.0	477.0	477.0	477.0	477.
	TOTAL M & I	654.7	653.5	651.4	651.8	643.1	781.7	835.6	799.4	652.0	657.9	657.3	657.
PULLMAN	Municipal	72.8	72.8	72.8	72.8	72.8	42.4	42.4	42.4	72.8	72.8	72.8	72.
	Industrial												
	Meat Products	2.2	1.8	2.0	2.1	2.1	2.1	2.1	2.1	2.4	2.4	2.1	2.
	Milk Products	2.2	2.1	2.4	2.5	2.8	2.8	2.7	2.5	2.2	2.1	2.0	2.
	TOTAL M & I	77.2	76.7	77.2	77.4	77.7	47.3	47.2	47.0	77.4	77.3	76.9	77.
LA GRANDE	Municipal	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.
	Industrial												
	Milk Products	0.9	0.9	1.0	1.1	1.2	1.2	1.1	1.1	0.9	0.9	0.8	0.
	Canning and Freezing	0	0	0	21.6	21.6	129.6	162.0	129.6	0	0	0	0
	TOTAL M & I	22.9	22.9	23.0	44.7	44.8	152.8	185.1	152.7	22.9	22.9	22.8	22.

TABLE D-6
LOWER SNAKE RIVER BASIN
PROJECTED RAW WASTE LOADS
2020

SERVICE AREA	CATEGORY	MONTH (1000 PEs) J	F	M	A	M	J	J	A	S	O	N	D
LEWISTON	Municipal	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185.0	185
	Industrial												
	Potato Processing	71.4	71.4	67.5	67.5	56.4	0	0	22.5	67.5	75.0	75.0	75
	Meat Products	7.3	5.0	5.6	5.9	5.9	5.9	5.9	5.9	6.6	6.6	5.9	6
	Milk Products	3.1	2.9	3.3	3.5	3.9	3.9	3.7	3.5	3.1	2.9	2.7	2
	Canning and Freezing	0	0	0	0	0	313.2	399.6	313.2	0	0	0	0
	Pulp and Paper	720.0	720.0	720.0	720.0	720.0	720.0	720.0	720.0	720.0	720.0	720.0	720
	TOTAL M & I	985.8	984.3	981.4	981.9	971.2	1228.0	1314.2	1250.1	982.2	989.5	988.6	989
PULLMAN	Municipal	108.0	108.0	108.0	108.0	108.0	60.1	60.1	60.1	108.0	108.0	108.0	108
	Industrial												
	Meat Products	2.6	2.1	2.3	2.5	2.5	2.5	2.5	2.5	2.7	2.7	2.5	2.
	Milk Products	3.1	2.9	3.3	3.5	3.9	3.9	3.7	3.5	3.1	2.9	2.7	2.
	TOTAL M & I	113.7	113.0	113.6	114.0	114.4	66.5	66.3	66.1	113.8	113.6	113.2	113.
LA GRANDE	Municipal	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.
	Industrial												
	Milk Products	1.4	1.3	1.4	1.5	1.7	1.7	1.6	1.5	1.4	1.3	1.2	1.
	Canning and Freezing	0	0	0	32.4	32.4	216.0	270.0	216.0	0	0	0	0
	TOTAL M & I	30.4	30.3	30.4	62.9	63.1	246.7	300.6	246.5	30.4	30.3	30.2	30.

As discussed in Appendix C, rapid industrial and population growth is expected, and total raw waste production in 2020 is projected to reach 1,250,000 PE. Even with adequate treatment of these wastes--under present technology, treatment that will remove 85 percent of the oxygen demanding materials is considered adequate--some 190,000 PE will remain to be assimilated by Snake River.

Agricultural

Sources of agricultural wastes reaching lower Snake surface waters include land erosion, animal wastes carried by runoff from pasture and feedlot areas, farm animals coming in contact with streams, and irrigation return flows. Wastes from these sources are minor in most areas; except for turbidity caused by the flushing action of the spring flood and erosion of farm lands in the upper Salmon and Palouse drainages, they have little effect on water quality.

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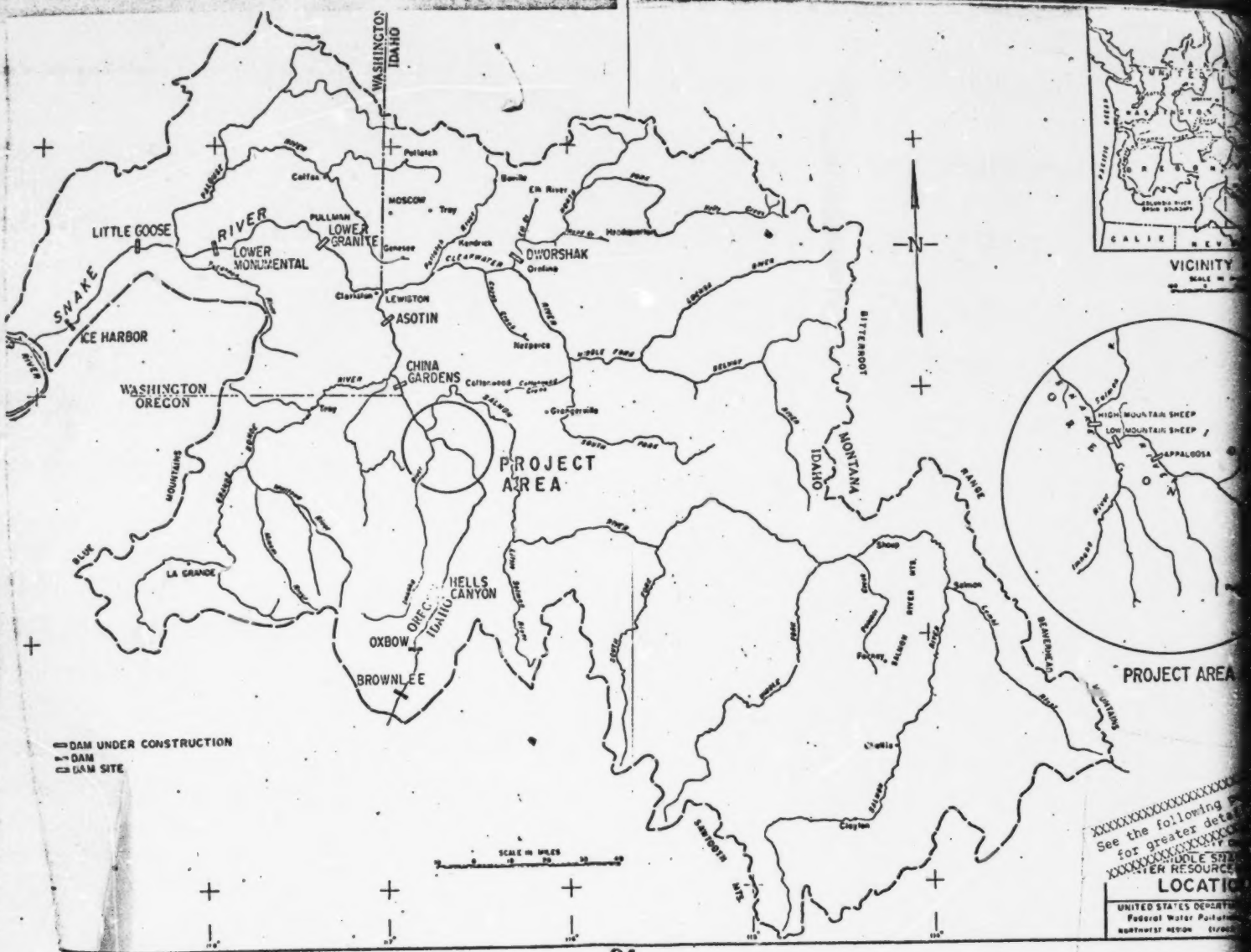
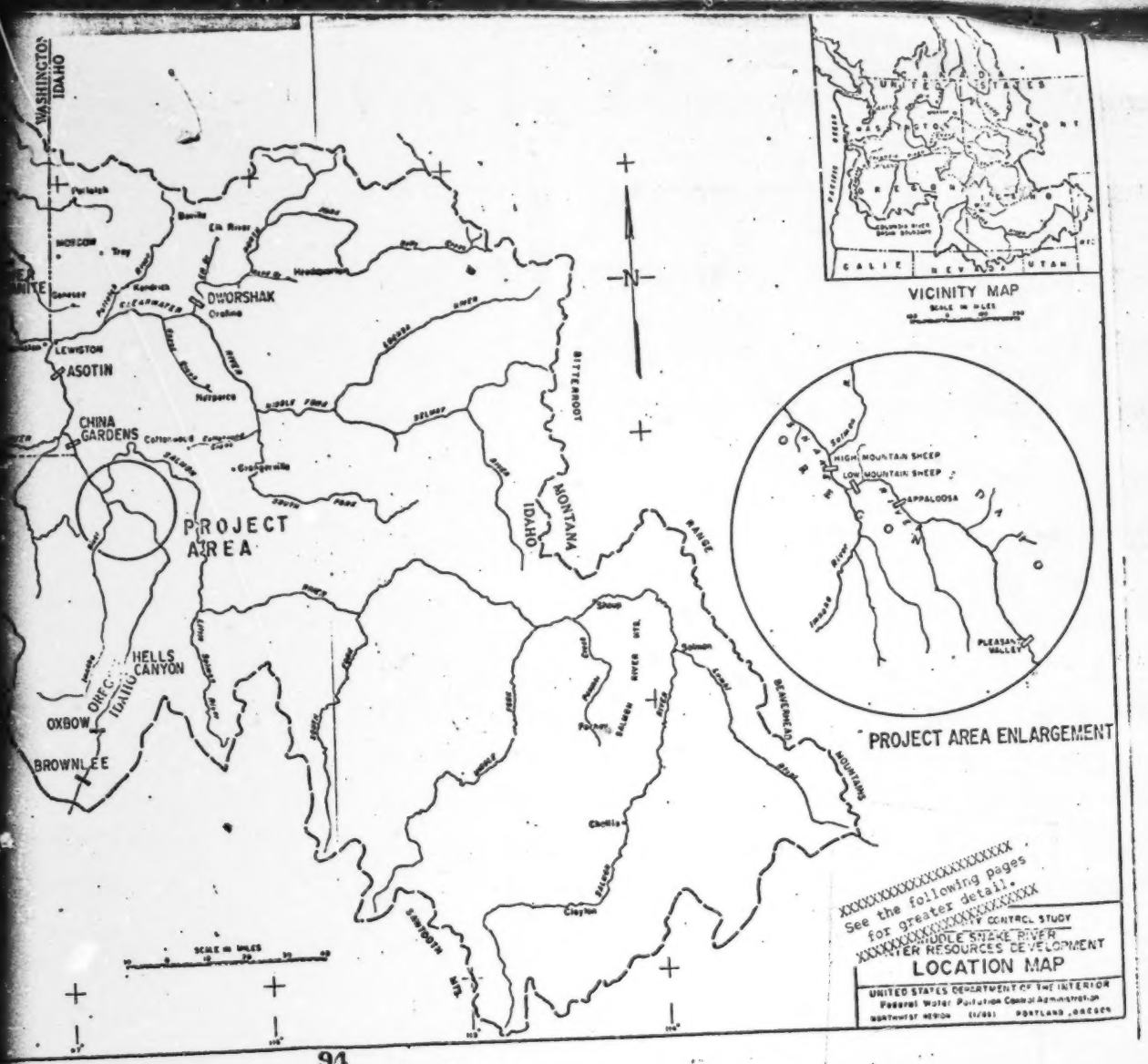
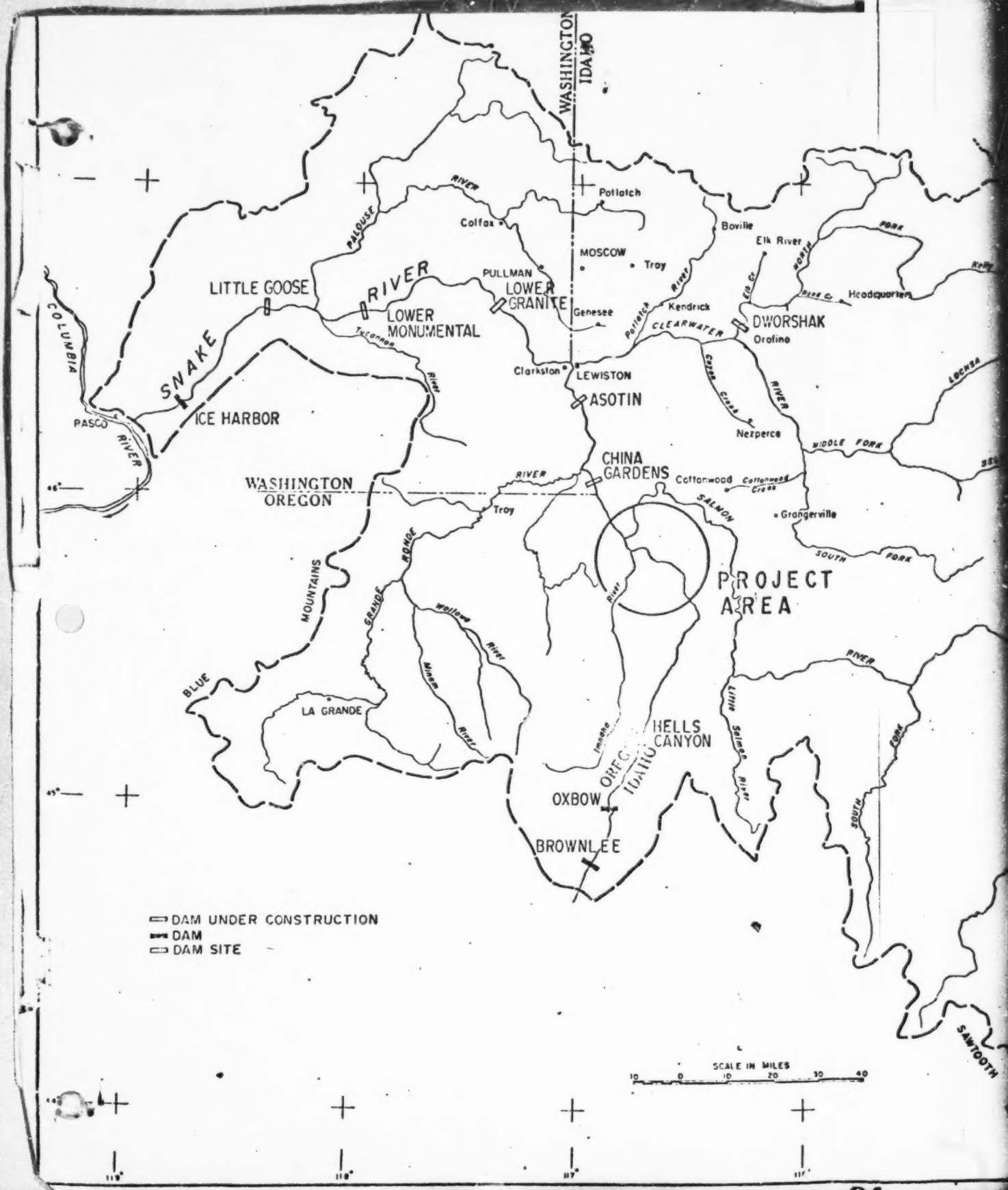

WASHINGTON
IDAHO
LITTLE GOOSE
SNAKE
RIVER
LOWER MONUMENTAL
ICE HARBOR
PULLMAN
LOWER GRANITE
MOSCOW
LEWISTON
ASOTIN
DWORSHAK
CHINA GARDENS
WASHINGTON
OREGON
PROJECT AREA
LA GRANDE
OXBOW
BROWNLEE
HELLS CANYON
BITTERROOT
MONTANA
IDAHO
VICINITY
PROJECT AREA
HIGH MOUNTAIN SHEEP
LOW MOUNTAIN SHEEP
DAM UNDER CONSTRUCTION
DAM
DAM SITE
SCALE IN MILES
LOCATIO


WASHINGTON
IDAHO
MONTANA
OREGON
IDAHO
DWORSHAK
LEWISTON
ASOTIN
CHINA GARDENS
PROJECT AREA
HELLS CANYON
OXBOW
BROWNLEE
BITTERROOT
SALMON RIVER MTS.
SEVEN DEVILS
CRAIG MTS.
BEAVERHEAD MOUNTAINS
SCALE IN MILES
N
VICINITY MAP
HIGH MOUNTAIN SHEEP
LOW MOUNTAIN SHEEP
APPALOOSA
PLEASANT VALLEY
PROJECT AREA ENLARGEMENT
xxxxxxxxxxxxxxxxxxxx
See the following pages
for greater detail.
xxxxxxxxxxxxxxxxxxxx
MIDDLE SNAKE RIVER
WATER RESOURCES DEVELOPMENT
LOCATION MAP
UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
NORTHWEST REGION (1/68) PORTLAND, OREGON


WASHINGTON
IDAHO
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Colfax
PALOUSE RIVER
MOSCOW
Troy
Boville
Elk River
PULLMAN
LOWER GRANITE
LITTLE GOOSE
RIVER
LOWER MONUMENTAL
Genesee
Kendrick
CLEARWATER
DWORSHAK
Orofino
Headquarters
COLUMBIA
SNAKE
Clarkston
LEWISTON
ASOTIN
ICE HARBOR
PASCO
Nezperce
CHINA GARDENS
Cottonwood
WASHINGTON
OREGON
Troy
Grangerville
SALMON
PROJECT AREA
BLUE MOUNTAINS
GRANDE RONDE
Wallowa River
Minam River
LA GRANDE
HELLS CANYON
OXBOW
BROWNLEE
SAWTOOTH
DAM UNDER CONSTRUCTION
DAM
DAM SITE
SCALE IN MILES
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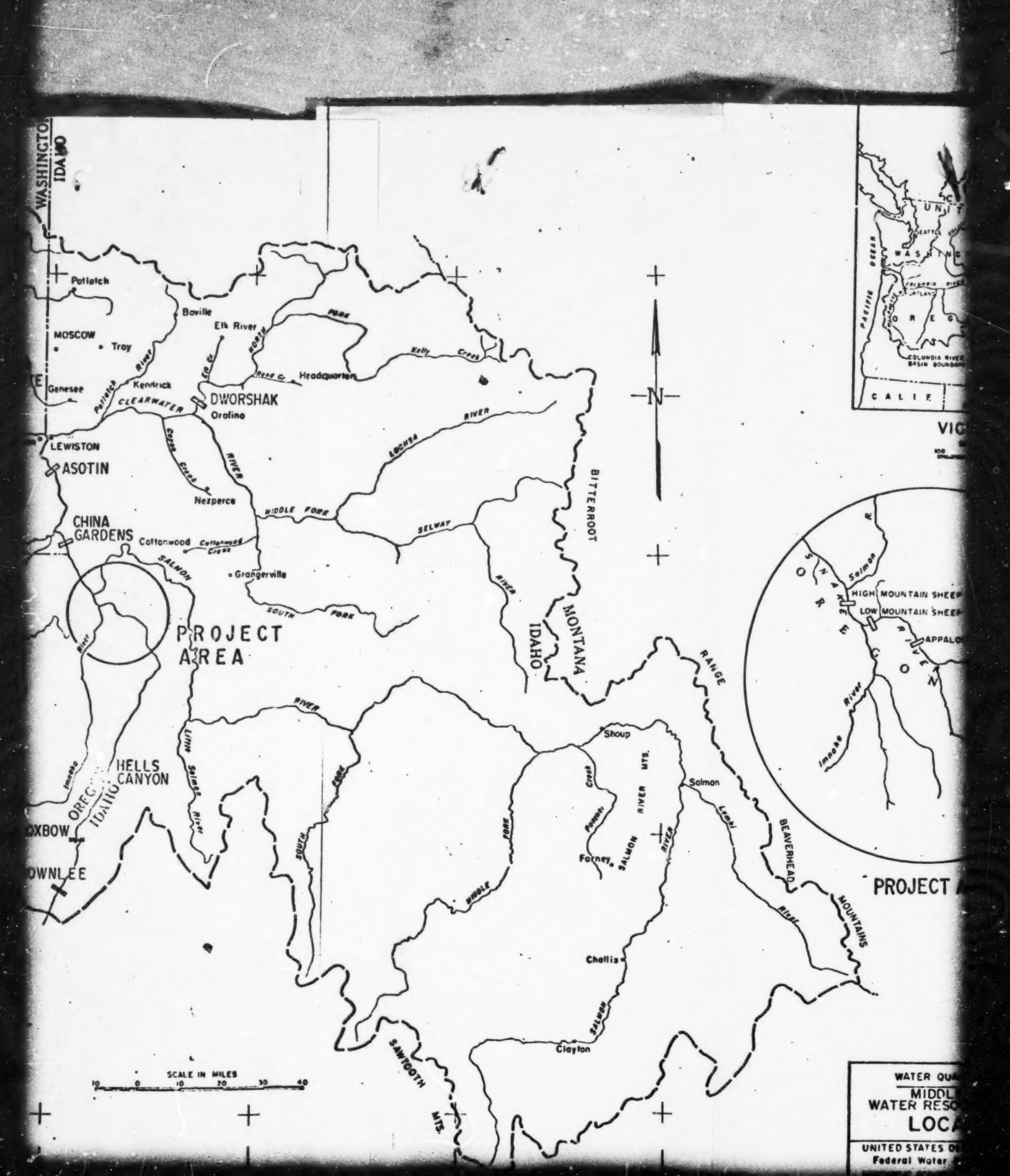
WASHINGTON
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Boville
Elk River
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Troy
Genesee
Kendrick
DWORSHAK
Orofino
CLEARWATER
LEWISTON
ASOTIN
Nezperce
CHINA GARDENS
Cottonwood
Grangerville
SALMON
PROJECT AREA
RIVER
SOUTH FORK
MIDDLE FORK
SELWAY
LOCHSA
BITTERROOT
MONTANA
IDAHO
RANGE
Shoup
Salmon
BEAVERHEAD
MOUNTAINS
Forney
Challis
Clayton
SAWTOOTH MTS.
HELLS CANYON
OREGON
IDAHO
OXBOW
OWNLEE
SCALE IN MILES
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N
HIGH MOUNTAIN SHEEP
LOW MOUNTAIN SHEEP
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WATER QUA
MIDDL
WATER RESO
LOCA
UNITED STATES DE
Federal Water

VICINITY MAP

SCALE IN MILES

100 0 100 200

PROJECT AREA ENLARGEMENT

N

Boville
Elk River
North Fork
Elk Cr.
Reed Cr.
Headquarters
Kelly Creek
DWORSHAK
Orofino
Lochsa River
Nezperce
Middle Fork
Selway
Cottonwood Creek
Grangerville
South Fork
PROJECT AREA
Bitterroot River
MONTANA
IDAHO
Salmon River Range
Shoup
Pahsimeroi
Panther Creek
Salmon River Mts.
Salmon
Lemhi River
Beaverhead Mountains
Forney
Middle Fork Salmon River
South Fork
Challis
Salmon River
Clayton
Sawtooth Mts.

MILES
20 30 40

WATER QUALITY CONTROL STUDY
MIDDLE SNAKE RIVER
WATER RESOURCES DEVELOPMENT
LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration